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A MANUAL OF HYGIENE

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A MANUAL OF HYGIENE

BY

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ROYAL SOCIETY OF MEDICINE
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WITH 94 ILLUSTRATIONS

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PREFACE

THIS Manual was from the outset designed to meet the needs of those seeking to obtain a Public Health Diploma. While following closely the lines thus prescribed it was found possible briefly to refer to most questions of special interest arising in connection with Public Health work, and the hope was expressed that the reader, in clambering up the path marked out for him, would find from time to time, without unduly straying from the beaten track, that he obtained glimpses of the prospect opening up as the ascent was made. It is now, however, more than ever clear that this ascent is no mean one, indeed, the snow line has long ago been passed by modern public health explorers and prudence requires that two guides should now conduct the climber over the concealed crevasses that lie in his path. The present authors, moreover, fully realise that, from the elevation now to be attained, wider horizons of knowledge, not visible when the original manual was written, have come into view, and they have, therefore, sought advice and help from investigators familiar with the newly annexed territories. They have, further, been very fortunate in securing a new chapter on Tuberculosis from Dr. James Niven, himself one of the pioneer explorers in that dark continent of disease : Dr. Niven has also revised the chapter on Sanitary Administration and Law. Mr. Kenneth Walker has contributed a new chapter on Venereal Disease and Dr. Kenneth Fraser one on School Hygiene. Dr. R. King Brown and Dr. M. Wynter Blyth have given considerable assistance in the revision of the sections of the book dealing with Air and Chemical disinfectants respectively, and Dr. D. Forbes has rewritten the chapter on Dwellings, Schools and Hospitals. To Dr. M. H. Gordon, C.M.G., Mr. J. H. Coste and Dr. E. Macrory our thanks are also due; to Mr. Austin and Mr. E. T. Swinson the authors are indebted for help, in connection with the section on drainage and with illustrations, respectively : from Miss E. J. Charlesworth they have also received assistance.

While the great extensions in knowledge relating to hygiene have necessarily entailed additions of much new material and while the attempt has been made to keep as far as practicable in touch with the new epidemiology and the new immunology, every effort has been exerted to restrict the volume as a whole within a reasonable compass.

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CHAPTER I

AIR

THE importance of atmospheric pollution was early recognised; indeed it was the custom at one time to look to miasmatic influences for explanation of almost any unusual prevalence of disease. Thus, to the inhabitant of the crowded, insanitary, plague-stricken London of three hundred years ago, "this most excellent canopy the air" may well have appeared at times "no other thing than a foul and pestilent congregation of vapours." In the light of modern knowledge, having regard to the sources of atmospheric impurity, to the ill effects likely to be associated with certain kinds of pollution, and to the extent to which, even under existing conditions, the operation of purifying agencies is interfered with, there is good reason for considering the subject of the relationship of air to disease one of the most important within the scope of hygiene.

Comparatively little has hitherto been done in the direction of preventing the addition of impurity, but much stress has been laid on the importance of securing free dilution, if not complete removal, of noxious matter by an adequate supply of "fresh" air. For a right appreciation of the whole question it is necessary first to consider the nature and physical properties of the "canopy" or covering of air which envelops the earth, and to deal with its chemical constitution, and with the characteristics and means of detecting the more commonly occurring impurities. It will then be possible to discuss more adequately the ill-effects of contaminating influences, and to appreciate more fully the operation of ventilation and heating in relation to the promotion of interchange of air.

THE PHYSICAL PROPERTIES OF THE ATMOSPHERE

Assuming that the atmospheric covering extends upwards to fifty miles beyond the earth's surface it may be calculated that there are some 10,000 million cubic miles of air encircling the globe. While, however, those layers of the atmosphere which adjoin the earth have the density of air as we know it, the outer layers become more and more attenuated. In order to understand how this is brought about it is necessary to refer to some of the elementary properties of gases.

A gas ever tends to expand. In solids what is called the force of cohesion comes into play, the same force is traceable in liquids, though in far less degree; but in the case of gases the constituent particles, in place of attracting, actually repel one another. Thus, if a gas be introduced into a flask, it pervades the entire space, and tending, as it does, to expand further, it exerts pressure upon the sides of the flask. If, in place of a rigid flask, an elastic enveloping surface, such as a bladder, be employed, the gas will dilate it until a sufficient counter-balancing resistance to further extension is produced by the bladder's tendency to contract. From the point of view of the gas it is under greater or less pressure from without. From the point of view of the enveloping surface an equivalent pressure is exerted upon it by the gas it contains.

In a gas, as in a liquid, the law that the pressure is equally distributed in all directions holds good. This principle, which was discovered in the first half of the seventeenth century as applying to fluids generally, is called the law of Pascal or Pascal's principle. It may be illustrated by the case of a quantity of gas in a closed receiver, fitted with tubular openings of equal size, in which pistons work in a direction at right angles to the surface of the receiver. In order to maintain equilibrium under these circumstances equal pressure must be applied to the several pistons, to counteract the expansive tendency of the gas. In the corresponding case, in which liquid fills such a receiver, if one piston be subjected to pressure, the like pressure must be applied to the other pistons, if they are to be maintained in position and prevented from being driven outwards by the pressure transmitted through the liquid. If the tubes in which the pistons fit have differing sectional areas, the pressure necessary to prevent any given piston being displaced must be increased in proportion to the area of that piston. The principle here involved is, of course, that of the hydraulic or Bramah's press, a machine in which the work done in displacing a piston of small sectional area, through a long distance, is transformed into work accomplished in raising a piston of large sectional area, through a small distance; thus great pressure can be exerted by the application of a small force.

In further illustration of the distribution of pressure in gases may be mentioned the fact that when the hand is stretched out, say palm upwards, the pressure exerted on the palm of the hand is counter-balanced by the upward pressure of the air on the back of the hand; as result, the fact that these forces operate is apt to be lost sight of. That such pressures have a very real existence is, however, strikingly shown in the experiment of the Magdeburg hemispheres, which consist of two hollow cups fitting accurately one into the other. These cups are readily separable under ordinary circumstances, the pressure of the air upon the outside of the cups being counteracted by the pressure of the air within them, but if the air inside the cups be exhausted, and the stopcock with which one of the cups is fitted, be closed, so as to prevent re-entry of air, considerable force is needed to pull the cups apart.

Weight of Air—The next point to be considered is that the atmosphere has weight. This discovery was also made in the first half of the seventeenth century. Galileo is said to have experimented with regard to the weight of a globe, filled at one time with ordinary air and at another with compressed air, and he is also said to have noted, in connection with certain fountains of the Grand Duke of Tuscany, that air would not rise in a pump more than eighteen cubits, *i.e.*, about thirty-two feet.

The lifting pump, in its simplest form, consists of a cylinder, fitted to a tube placed in a reservoir of water. At the junction of the tube and cylinder, and covering the opening of the tube, is a valve which opens upwards. In the cylinder a piston is worked by means of a lever (the handle of the pump), and this piston is perforated by an opening, covered above, on the upper surface of the piston, by a valve, which also opens upwards. If the piston be raised, its valve remains, owing to atmospheric pressure, closed down over the opening in the piston; the air beneath the piston, and between the two valves, tends to become rarefied as the piston ascends, and the lower valve therefore opens, and air (or water) from below is sucked into the cylinder. Inasmuch as the atmospheric pressure is continuously acting on the surface of the water in the reservoir outside, while within the pump the pressure tends to diminish when the piston ascends, the level of the water must rise in the tube. As the piston descends, however, at the end of the stroke, the upper valve opens and the lower valve closes in virtue of the pressure now transmitted through the opening in the piston. When the piston again ascends, a further rise in the water level inside the pump occurs; water, as the strokes succeed one another, enters the cylinder, then passes upwards through the perforated piston, and is ultimately raised to the level of the spout, and escapes.

The fact that water rises in a pump, was at one time explained by saying that Nature abhorred a vacuum; the question arose why this statement of the case, which is really no explanation at all, no longer applied when the height, through which the piston was raised, exceeded eighteen cubits, or thirty-two feet. Torricelli, a pupil of Galileo, seems to have argued that the water must be raised in the pump by the pressure of the atmosphere, and he concluded that as this pressure was capable of supporting a column of water about thirty-two feet in height, it could also support a proportionately smaller column of a more dense material, such as mercury. In fact, mercury being thirteen times as heavy as water, the column should be only one-thirteenth of thirty-two feet, *i.e.*, about thirty inches high. In the year 1643, Torricelli made his famous experiment of inverting a glass tube, more than thirty inches in length and filled with mercury, over a bowl containing this metal, and he demonstrated that the mercury fell in the tube, leaving a vacuum behind it, and coming to rest at a height of about thirty inches above the surface of the mercury in the bowl.

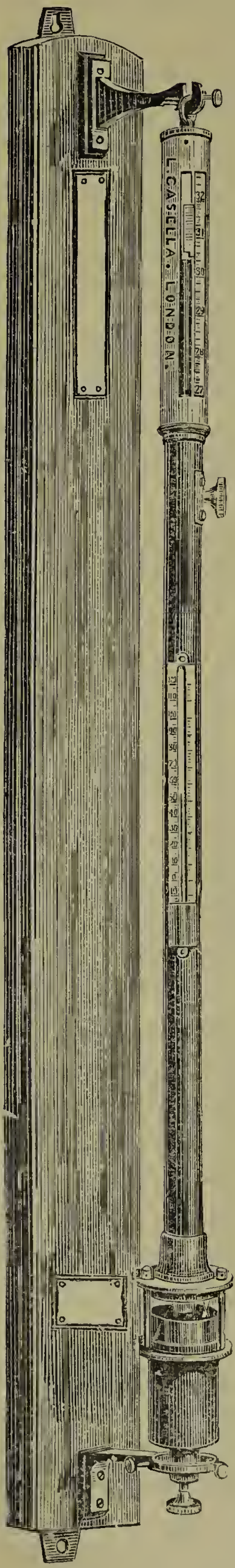


FIG. 1.
Fortin's Barometer.

Pascal subsequently showed that the height of the mercurial column supported steadily diminished at increasing distances above the earth's surface, as more and more air was left beneath, and a less and less weight of air remained above the site of the experiment. Thus at the top of the Puy de Dôme he found the mercurial column supported was about three inches less in height than it was at the bottom of the mountain.

The experiment of Torricelli demonstrated that the atmosphere has weight, and the appliance he used, *i.e.*, a barometer (from the Greek words *βάϱος*, weight, and *μέτϱον*, a measure), has been found admirably adapted to act as a measure of that weight. The form of *mercury barometer* now commonly used for precise measurement of atmospheric pressure, is that known as Fortin's cistern barometer, shown in the annexed figure.

Through the glass at the lower part of this instrument the surface of the mercury in the cistern can be seen. From the brass covering of the cistern (just above the glass) an ivory pin descends towards the mercury. Before taking a reading of the upper surface of the mercury in the tube, the extremity of this pin must be accurately adjusted, so that it just touches the surface of the mercury in the cistern.

The reason for taking this precaution is that the level of the mercury in the cistern fluctuates slightly with variations of atmospheric pressure, and it is therefore necessary to bring the zero of the scale, on the upper part of the barometer tube, into exact correspondence with that level. This is done by turning the screw (seen at the lower extremity of the instrument) and thus bringing pressure to bear upon the under surface of the cistern, which is made of flexible leather. By this expedient the lower extremity of the ivory point, from which the scale is measured, can be made to correspond exactly with the surface of the mercury in the cistern. It may be further noted that a piece of chamois leather is fitted round the tube containing the column of mercury, at the point where it is inserted into the case of the cistern; this means of junction, while it prevents escape of mercury, does not exclude the transmission of the atmospheric pressure, through the pores of the leather, to the surface of the mercury in the cistern.

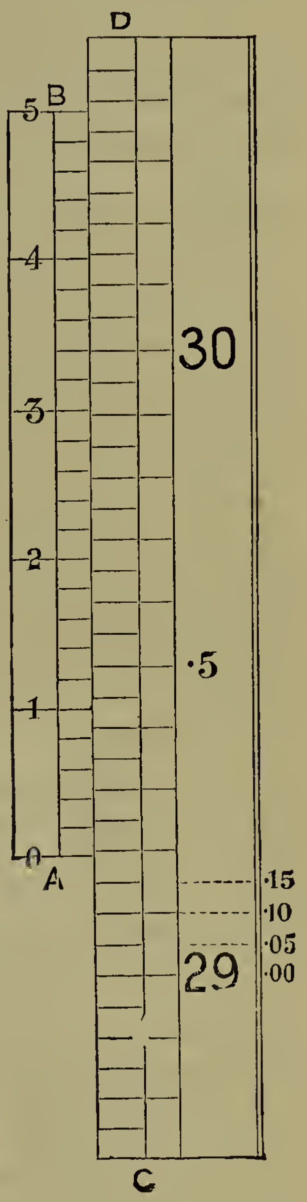


FIG. 2.—Barometer Scale CD and Vernier AB, showing a reading of 29·184 inches.

The ivory point having been adjusted, the reading of the thermometer (seen in the figure at about the middle of the barometer tube) may be taken—the object of ascertaining this reading will be seen presently. Attention should then be directed to the upper surface of the mercurial column in the barometer. Here the adjustable scale called, after its inventor, a "vernier," is situated. This must be set so that its lower margin is precisely tangential to the convex upper surface of the mercurial column. The reading is then made by noting—first, the division on the fixed scale immediately below the zero of the vernier; and, secondly, the number of divisions which have to be counted, from zero upwards, on the scale of the vernier, before one of the divisions of the latter is found to be in a straight line with a division on the fixed scale.

If the number of divisions so counted be multiplied by ·002, and the result added to the first reading exhibited on the scale, the final reading of the barometer is obtained. In the figure the first reading noted is 29·15, and seventeen divisions in the vernier scale have to be counted, therefore 29·15 + ·034, or 29·184, is the final reading. Or more shortly, the first line on the vernier scale, which is in a straight line with a division on the fixed scale, may be read off at once as ·034, as it is beyond the 3 on the vernier scale (supplying the figure for the second place of decimals) and is situated two-fifths, *i.e.*, *four-tenths*, of the distance between 3 and 4, above the 3 on that scale (supplying 4 as the figure for the third place of decimals).

The principle of working with the vernier will be understood if it is borne in mind that twenty-five divisions on the vernier correspond to twenty-four on the scale. Going downwards, therefore, from two divisions which are in a straight line, it is necessary to count twenty-five divisions of the vernier before again reaching two divisions in a straight line; the first division of the vernier reached will be one twenty-fifth of a scale division above the first division of the scale, the second two twenty-fifths of a division, and the seventeenth seventeen twenty-fifths of a division above the corresponding division of the scale. The distance last named is that of the height of the mercurial column above the first reading taken. Each division of the fixed scale represents one-twentieth of an inch, therefore the vernier reading to be added is clearly $\frac{17}{25} \times \frac{1}{20}$ inch, or ·034.

Certain corrections must be applied to the reading of the barometer thus ascertained. Some of these are corrections which apply to the particular barometer used—they are, so to speak, personal to the instrument; thus, *index errors* include errors in graduation, or in the position of the zero of the scale; the correction for *capacity*, *i.e.*, for change of level of the mercury in the cistern, has also to be made, unless this correction has already been allowed for in taking the reading; thirdly, the correction for *capillarity* must be applied so as to compensate for capillary depression, which causes the barometric height to be somewhat under-estimated. The corrections necessary to compensate for these three kinds of error, at every half-inch of scale, are furnished in a table which is supplied with instruments sent out from Kew Observatory.

Other corrections are those relating to *temperature*, to *reduction to sea level*, and to *unequal intensity of gravity*. Correction for temperature is necessary owing to the expansion of mercury under the influence of heat, and to the alterations effected in the scale of the barometer itself from a like cause; these factors must be allowed for in all precise observations. Hence the need for taking a reading of the thermometer, as described above, at the time when the reading of the barometer is made. The necessary correction for temperature is ascertained by the help of tables which give the amount of allowance to be made, for all ordinary temperatures and heights of the barometer. Reduction to sea level is also effected by means of tables. Roughly speaking, for each 100 feet above sea level, one-tenth of an inch must be added to the barometric reading. The correction for unequal intensity of gravity requires to be taken into consideration when observations are made at places in which the intensity of gravity markedly differs, as, for example, near the poles and at the equator.

A form of barometer which possesses the advantage, as compared with the mercury barometer, of far greater sensitiveness of indication, is that known as Jordan's glycerine barometer. The height of the column of glycerine supported by the atmospheric pressure is about twenty-seven feet, and the instrument has thus far greater range of variation, in correspondence with small fluctuations of pressure, than is the case with the mercurial barometer. A water barometer has, of course, even greater range than a glycerine barometer, but the vapour tension in the vacuum is so considerable a source of error, as to militate against the use of this form of instrument.

The *aneroid barometer* derives its name from the absence of any liquid in its construction. It consists of a cylindrical metal box, partially exhausted of air, the lid of which is made of thin elastic corrugated metal which readily yields to variations of the atmospheric pressure. When the pressure increases the lid is pressed inwards, and when it decreases, the elasticity of the lid aided by a spring causes it to return outwards. These movements can by a suitably arranged set of levers be communicated to an index which moves round a graduated dial. The instrument must be calibrated by comparing its movements with those of an ordinary barometer. It is liable to get out of order and must be corrected periodically by comparison with a mercury barometer. Being very sensitive and portable, it is of much value for ascertaining heights when climbing mountains, or during balloon or aeroplane ascents.

The *barograph* is an aneroid barometer fitted with a lever which records the movements of the barometer on a revolving drum, thus exhibiting in graphic form the variations of the atmospheric pressure from hour to hour.

The *syphon* may be here referred to, as it also strikingly illustrates the influence of atmospheric pressure. It consists of a bent tube, open at the ends, and having one arm longer than the other. When this tube is filled with liquid, and its two arms are placed, one (the shorter) in a vessel or reservoir containing liquid, and the other (the longer arm) in a vessel or reservoir placed on a somewhat lower level and also containing liquid, it is found that flow occurs, up the shorter arm and down the longer arm of the syphon, until the upper reservoir is emptied, or until the level of the liquid in the two reservoirs becomes the same. The phenomenon in question may be explained as follows:—At the point where the shorter arm meets the surface of the liquid in the higher reservoir, the pressure on the column within the tube, tending to promote the flow up the short arm, must be the atmospheric pressure, less the weight of a column of liquid whose height is equal to that of the point of junction of the long and short arms, above the level of the liquid in the higher reservoir. Similarly, at the point where the longer arm meets the surface of the liquid in the lower reservoir, the pressure on the column of liquid, tending to oppose its flow into the lower reservoir, is the atmospheric pressure, less the weight of a column of liquid whose height is equal to that, of the point of junction of the long and short arms of the syphon, above the level of the liquid in the lower reservoir. As the height of the column, determining the weight to be deducted, is greater in the latter than in the former case, the pressure tending to promote the flow, from the higher to the lower reservoir, exceeds that tending to oppose it, and thus the discharge takes place.

From what has been said concerning the weight of the atmosphere, it will now be clear that the strata of air near the earth's surface, which have to bear the weight of a considerable quantity of overlying atmosphere, must be far more dense than more outlying strata which are subjected to less pressure. The experience gained in mountain, balloon and aeroplane ascents may be referred to as showing the effect of breathing rarefied air. The "mountain sickness" of the higher Andes and Himalayas has been experienced at elevations of less than four miles, while in the famous balloon ascent of Messrs. Glaisher and Coxwell the furthest limit of penetration into the upper regions of the air was less than seven miles, but those observers narrowly escaped with their lives. On the other hand, the results of exposure to "compressed air" are illustrated in the so-called "Caisson disease" and in "Divers' palsy."

Boyle and Mariotte's Law—The pressure of the atmosphere due to the superincumbent weight of air is, if the air be at rest, the same for all points in the same horizontal layer, and the density is also the same for such points. On comparison of layers at different horizontal levels, the pressure and density of course increase on descending or approaching the earth, and diminish on ascending. But the volume of a given amount of gas varies inversely as its density, the density of a quantity of air, occupying one cubic foot, being doubled when the air is compressed so as to occupy half a cubic foot, *i.e.*, only half the original volume. Boyle and Mariotte nearly 270 years ago independently demonstrated the law, which governs the relationship between pressure and density on the assumption that temperature remains constant. This law may be stated, for the case of a closed receiver, as being that the pressure is proportional to the mass of the contained gas. Or, generally, the pressure exerted by a gas is proportionate to its density, and therefore inversely proportionate to its volume, temperature remaining constant. Thus, if half the mass of a quantity of air contained in a flask be removed, the pressure exerted on the sides of the flask, per unit of surface, will be found to be only half what it previously was, the volume of the air remaining in the flask having expanded to double the original volume, while its density is now only half the original density. The law discovered by Boyle and Mariotte may be also expressed as follows:—If V and V^1 be the volumes occupied by the same mass of gas, P and P^1, D and D^1 the corresponding pressures and densities, then

$$\frac{P}{P^1} = \frac{V^1}{V}, \text{ or what comes to the same thing } \frac{P}{P^1} = \frac{D}{D^1}.$$

Experimental verification of the truth of this law may be made by means of what is called Mariotte's tube. This consists of a glass tube of uniform bore, so shaped that, when fixed to an upright support, it has two vertical arms connected below by a curved intermediate portion. One vertical arm is short and closed at the end, the other much longer, and open, so that mercury can be poured into it. Each of the arms has marked on it a graduated scale. A little mercury is poured into the tube so as to occupy its lower curved intermediate portion, and also so much of the extent of each of the vertical arms as will bring the mercury up to the two zero points on the graduated scale. The level in the two limbs is then the same, and, as the mercury rests in the curved portion of the tube, one surface, that situated at the zero of the longer vertical limb, is under the atmospheric pressure exerted through the open tube, while the other surface, that situated at the zero of the shorter limb, is also under the atmospheric pressure exerted by the imprisoned column of air. If mercury be now poured into the longer limb, the air in the shorter limb is compressed, and if the addition of mercury be continued, until the top of the column in the longer limb stands at the height indicated on a barometer above that of the shorter limb, the air in the shorter limb will be found to occupy only half the volume it originally filled. The pressure exerted on the imprisoned air is now the atmospheric pressure plus the weight of the mercury in the longer limb, this weight being itself equal to the atmospheric pressure. The imprisoned air is therefore subjected to twice the atmospheric pressure, and its volume has therefore diminished to one half its original volume. If mercury be added in the longer limb until the reading on the scale, giving the height of the top of the column of the longer above that of the shorter limb, is twice the barometric height, the imprisoned air will be subject to the atmospheric pressure plus twice the atmospheric pressure, *i.e.*, to three times the atmospheric pressure, and its volume will now be found to be one-third of its original volume.

In thus describing the relation between pressure and volume it has been assumed that the temperature remains constant. It is necessary to consider what happens if the temperature of a gas be raised or lowered. Gases, like solids and liquids, expand when they are heated, but the expansion of gases is far more marked and more regular than that of solids and liquids. The meaning of this statement will be rendered more clear when some of the simpler phenomena resulting from applying heat to bodies have been considered.

Temperature—When two bodies are placed in contact, heat passes from that which has the higher temperature to that which has the lower temperature ; if no heat pass the bodies are said to have the same temperature. As bodies expand when they are heated, change of temperature can be measured by ascertaining the alteration of volume which occurs. In the ordinary thermometer the expansion of mercury in a graduated glass tube is adopted as the standard of change of volume to which all questions of temperature are referred.

In constructing a *thermometer* a glass tube with a very fine and uniform bore, and having a bulb blown at one end of it, is used. Upon the fineness of the bore depends the sensitiveness of the instrument, its ability to indicate small differences of temperature ; upon the uniformity of bore depends the accuracy of the correspondence observed between lengthening of the mercurial column and increase of temperature.

In filling the thermometer the bulb is first heated causing the contained air to expand and find its way out through the fine glass tube. The mouth of the latter is then immediately plunged into a vessel containing pure mercury. As the air left in the bulb and fine tube now contracts through cooling the mercury will rise in the tube and reach the bulb.

By alternately heating and cooling the bulb, more and more mercury is drawn into it. The instrument is then placed in a furnace, in a sloping position, bulb downwards, until the mercury boils, and its vapour has expelled all air from the bulb and tube. The tube is then hermetically sealed and, on cooling, a continuous column of mercury is found filling the bulb and part of the tube, the other part being left empty.

The next proceeding is to determine the fixed points, which correspond to the temperature of melting ice and to that of the steam given off by boiling water at ordinary atmospheric pressure. The thermometer is first surrounded by melting ice, contained in a vessel from the lower part of which the water produced, as melting proceeds, can escape ; when the level of the mercury ceases to fall " freezing point " has been reached ; a mark is scratched with a diamond on the stem at this point, which indicates the position of zero on the Centigrade scale. Then, to determine the other fixed point, the thermometer is immersed in the steam arising from pure water boiling under ordinary atmospheric pressure, and, when the level of the mercury has again become stationary, a mark is made on the stem to indicate "boiling point," 100° C. If the atmospheric pressure is not exactly 760 m.m. a small correction requires to be made as regards " boiling point " ; roughly speaking, a difference of 27 m.m. in atmospheric pressure cases a difference of 1° C. in the temperature of the steam produced.

In the Centigrade system the scale between the above-mentioned two fixed points is divided into 100 degrees. In Réaumur's scale "freezing point" is still zero, but "boiling point" stands at 80°. Thus a degree Réaumur is five-fourths of a degree Centigrade. It is easy to calculate, therefore, to what temperature Centigrade any given temperature Réaumur corresponds, and *vice versâ.* In the case of the Fahrenheit scale freezing point is no longer zero, but 32° F.; while boiling point is 212° F. Thus the range of temperature, which in the Centigrade scale is represented by 100°, and in the Réaumur scale by 80°, is in the Fahrenheit scale represented by 212° — 32 or 180°. Hence a degree Fahrenheit is equivalent to $\frac{100}{180}$, or $\frac{5}{9}$ths of a degree Centigrade, and to $\frac{80}{180}$ths or $\frac{4}{9}$ths of a degree Réaumur. Thus $\frac{F-32}{9}=\frac{C}{5}=\frac{R}{4}$.

In converting degrees Fahrenheit into those of one of the other scales, or *vice versâ*, it is always necessary to have regard not only to the range covered by a degree, but also to the position of zero point on the Centigrade and Réaumur scales, as compared with freezing point on the Fahrenheit scale. In the case of thermometers, as has been already seen with regard to barometers, certain corrections of the observed reading require to be made. Thus, what is called displacement of the zero point occurs, from gradual contraction of the bulb, due to a molecular change in the glass; this alteration is rapid at first, but becomes negligible after a year or so. It may be almost entirely avoided, therefore, by delaying the process of graduation until some time after the thermometer has been sealed. The instruments employed for precise observations should have been carefully tested—a Kew certificate is regarded as essential in the thermometers used in scientific work.

Liquids other than mercury have been used in constructing thermometers; thus, an alcohol thermometer may be employed when very low temperatures, below the point (about — 39° C.) at which mercury congeals, have to be registered.

Self-registering or *maximum* and *minimum thermometers* indicate the highest and lowest temperatures recorded during any particular period. In Rutherford's minimum thermometer alcohol is the fluid used, and a small index, usually of glass, is placed in the tube, which should be kept horizontal, or nearly so. When the column of alcohol expands it flows past the index, but when it contracts it does not leave the index behind it, but draws it along by capillary attraction, so that the point at which it ultimately rests indicates the lowest temperature attained. In Rutherford's maximum thermometer, a mercurial thermometer, whose stem is horizontal, is used and a steel index is employed. This is pushed before the mercurial column as it expands, and is left behind when the mercury contracts. Thus the hinder end of the index shows the highest temperature attained. The thermometer can be set by bringing back the index, usually by means of a magnet, into contact with the end of the column of mercury. This instrument is liable to fail completely after a few years' use, as chemical action occurs, and the index is then apt to become wetted by the mercury.

In Phillips's maximum thermometer the column of mercury is broken by a small bubble of air. When the mercury expands it pushes the air and the detached mercury in front of it, but when the temperature is lowered the detached mercury is left behind, the air expanding as the end of the column, which stretches up to the air bubble, recedes. In Negretti's maximum thermometer a constriction exists near the bulb, which allows an expanding column of mercury to pass, but is able to offer sufficient resistance to prevent the cohesion of the mercury drawing the column back as the bulb cools.

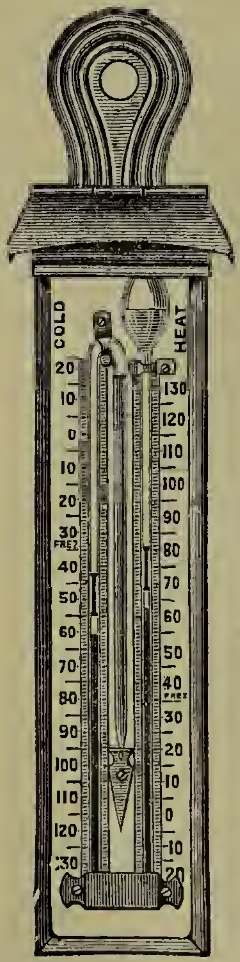


Fig. 3.
Six's Thermometer.

Six's thermometer consists of a U-tube one end of which opens into a long shaped bulb bent on the limb and filled with alcohol while the other end is expanded into a small pear-shaped bulb partly filled with alcohol vapour. The bend of the U is filled with mercury and the alcohol in the bulb overflows into the limb of each of these and rests on the mercury column so that from bulb to bulb there is a continuous column—alcohol, mercury, alcohol. When the alcohol in the long bulb expands and contracts on heating and cooling respectively it pushes the mercury column down in one limb and up in the other and *vice versâ*, the height to which it reaches in either limb being registered by a small glass and wire index which can be pushed up in the lumen of the tube by the mercury and brought back to position by a magnet. This thermometer therefore not only acts as a maximum and minimum one but by giving the double reading corrects itself.

Expansion—In describing the expansion of bodies under the influence of heat it is customary to make use of the expression "co-efficient of expansion." The co-efficient of cubical expansion of a body is the increase, per unit of volume of the body, when its temperature is raised from zero to one degree. In the case of solids and liquids, the co-efficient of expansion varies for different substances. Thus mercury expands under the action of heat to a much greater extent than glass, and upon this fact the use, in the ordinary thermometer, of a column of mercury in a glass tube depends. Again, the co-efficients of expansion, in the case of solids and liquids, show some increase as the temperature is raised, though it may be noted that the co-efficient of expansion of mercury is well-nigh constant at all ordinary temperatures, another fact of importance in connection with the use of mercury in the thermometer.

In the case of gases, however, it is found that the co-efficient of expansion is practically the same in all instances. In other words, if V_0 and V_t be the volumes of a gas at zero and at $t°$ Centigrade, respectively, then, if the pressure remain the same,

$$V_t = V_0\,(1 + at),$$

where $a = \cdot 003665$ nearly, *i.e.*, approximately, $\frac{1}{273}$, and where for ordinary purposes this value may be regarded as constant, whatever the nature of the gas considered. Again, the value of a remains practically the same for all the ordinary temperatures indicated by the mercurial thermometer. It will now be seen what is meant by saying that the expansion of gases is more regular than that of solids and liquids.

In discussing the increases of volume caused by increase of temperature the pressure was assumed to remain constant; consideration of the manner in which pressure varies with increase of temperature, if the volume remains the same, may now be undertaken. If P_t and P_0 denote the pressures per unit of surface of a gas, contained in a vessel of fixed volume, at temperatures $t°$ and zero Centigrade, respectively, it is found that

$P_t = P_0\,(1 + at)$ the value of a being, as before, $\cdot 003665$ nearly.

This is sometimes called the law of Charles.

Thus, if the volume remains unaltered, the pressure increases with temperature, to the extent indicated by multiplying it by the factor $(1 + at)$, and it has been seen that, if the pressure remains constant, the volume increases with temperature to the extent indicated by multiplying it by this same factor. Boyle's law, it will be remembered, is to the effect that the product of the volume and pressure always remains the same, provided the temperature remains constant.

It may be stated generally that the product of the volume and pressure of a gas at $t°$, is $(1 + at)$ times the product of the volume and pressure of the gas at zero, or, as it may be expressed in signs,

$$(VP)_t = (VP)_0\,(1 + at).$$

Of this general statement the two previously given are of course particular cases, for, if in the general statement the volume be supposed to remain always the same, the product of volume and pressure is proportional to the pressure only, and thus

$$P_t = P_0 (1 + at),$$

while, on the other hand, if the pressure be supposed to remain the same, the product of volume and pressure is proportional to the volume only, and

$$V_t = V_0 (1 + at).$$

As a gas increases by $\frac{1}{273}$ of its volume for each degree Centigrade, it follows that if the temperature of a given volume at 0° were raised to 273° C., the volume would be doubled, while if the temperature could be lowered to — 273° C., and the law of contraction continued to hold good, the volume would entirely disappear. The point — 273° C. is therefore referred to as the absolute zero of temperature, and temperatures reckoned from this point are spoken of as absolute temperatures. If T denote the absolute temperature, the relation between the volume, pressure and temperature of a gas, assumes the simple form $\frac{VP}{T} = \text{constant}$.

The following examples of the application of these principles may be given :—

(i) To what volume would 1000 c.c. of a gas at 15° C. expand if the temperature rose to 70° C. ?

Here the pressure remains constant, and V_0, the volume at zero, must be multiplied by $(1 + 15a)$ to give V_{15} the volume at 15°, a being ·003665,

$$\text{or } V_{15} = (1 + 15a)V_0$$

and V_{70}, the volume at 70° must be given by the equation

$$V_{70} = (1 + 70a)V_0$$

From the first equation, $V_0 = \frac{V_{15}}{1 + 15a}$ and from the second equation,

$$V_0 = \frac{V_{70}}{1 + 70a}$$

$$\therefore \frac{V_{15}}{1 + 15a} = \frac{V_{70}}{1 + 70a}$$

Multiplying crosswise

$$V_{70}(1 + 15a) = V_{15} (1 + 70a) = 1000 (1 + 70a)$$

$$\therefore V_{70} = \frac{1000 \times 1{\cdot}25655}{1{\cdot}054975} = 1191{\cdot}07 \text{ c.c., nearly.}$$

(ii) Calculate the volume to which 1000 c.c. of air expand when the temperature rises from 50° F. to 90° C.

Here again the pressure remains constant, but the temperatures are now expressed in different scales. They must, if the value ·003665 is to be applied to a, be both referred to the Centigrade scale.

50° F. is 18° F. above freezing point, the zero of the Centigrade scale, and each degree Fahrenheit is $\frac{100}{180}$ or $\frac{5}{9}$ths of a degree Centigrade.

$$\therefore\ 50^\circ \text{ F.} = \frac{5}{9}\, 18^\circ \text{ C.} = 10^\circ \text{ C.}$$

Proceeding as before $V_{10} = (1 + 10\alpha)V_0$

and $V_{90} = (1 + 90\alpha)\ V_0$

$$\therefore\ V_{90}\,(1 + 10\alpha) = V_{10}\,(1 + 90\alpha)$$

V_{10} is the volume at 10° C., *i.e.*, at 50° F., *i.e.*, 1000 c.c.

$$\therefore\ V_{90}\,(1 + \cdot 03665) = 1000\,(1 + \cdot 32985)$$

$$\therefore\ V_{90} = \frac{1329\cdot 85}{1\cdot 03665} = 1282\cdot 83 \text{ c.c., nearly.}$$

(iii) A gas initially at volume 4500 c.c., temperature 100° C., and a pressure represented by 75 cm. of mercury, has its pressure increased by 1 cm. of mercury, and its temperature raised to 200° C. Find its final volume.

Supposing the temperature to remain at 100° C., an increase of 1 cm. of pressure would cause the volume of the gas to diminish to the value V, where $V \times 76 = 4500 \times 75$, by Boyle's law as to the constancy of the product of volume and pressure, when the temperature remains the same.

If this volume of gas $\left(V = \frac{4500 \times 75}{76} \text{ c.c. at } 100^\circ \text{ C.}\right)$ be lowered to zero temperature, the pressure now remaining constant at 76 cm. of mercury, its volume will be further diminished in the proportion represented by dividing it by $(1 + 100 \times \cdot 003665)$, *i.e.*, by $1\cdot 3665$.

Thus the new volume will be $\frac{4500 \times 75}{76 \times 1\cdot 3665}$ c.c.

If this new volume be now raised to 200° C., the pressure still remaining constant at 76 cm. of mercury, it will increase in the proportion represented by multiplying it by $(1 + 200 \times \cdot 003665)$, *i.e.*, by $1\cdot 733$.

Thus the final volume of the gas at 200° C. and 76 cm. pressure

$$= \frac{4500 \times 75}{76 \times 1\cdot 3665} \times 1\cdot 733 = 5632 \text{ c.c. nearly.}$$

Mixtures of Gases and Vapours—The word vapour is applied to the gaseous state of bodies usually met with in the solid or liquid condition—thus it is customary to speak of water vapour, the vapour of arsenic, and so on; while the term gas is applied more especially to bodies commonly met with in the gaseous condition. If a liquid be allowed to evaporate into an empty space, it at first rapidly assumes the form of vapour, and as the amount of the latter is augmented, the "elastic force," "pressure," or "tension," as it is called, exerted by it upon the boundaries of the space will increase. At length, however, a limit will be reached, beyond which no more liquid will pass into a state of vapour; the space is then said to be saturated, and the vapour contained in it is at maximum density and pressure, for the temperature concerned. If the temperature be raised, the maximum density and pressure increase; or, in other words, the higher the temperature, the greater the quantity of vapour required to saturate a given space.

If a liquid evaporate into a space filled with dry gas, saturation will be attained more gradually than in the case of evaporation into a vacuum, but, ultimately, the same amount of liquid will be evaporated; again, when a gas is saturated with vapour, the actual pressure of the mixture is the sum of the pressures due to the gas and vapour considered separately. These two laws, concerning mixtures of vapour and gas, are sometimes called, after the name of their discoverer, Dalton's laws. It may be noted that experiments seem to show, as regards the first law, that it is not, strictly speaking, exact, inasmuch as to a very slight extent the quantity of vapour taken up is diminished, as the density of the gas simultaneously occupying the space is increased. Again, the second law holds good whether the quantity of vapour reaches the point of saturation or falls short of it; thus it may be stated generally that in the case of a mixture of gases and vapours, the total pressure, on the walls of the containing vessel, is the sum of the pressures due to the several gases and vapours considered separately.

A mixture of air and vapour obeys the ordinary laws applicable to mixtures of gases, provided none of the vapour becomes condensed; it is because of the liability to the occurrence of condensation on the part of the vapour, as the result of changes of temperature and pressure, that the subject of mixtures of gas and vapour requires special consideration. The vapour in question in dealing with air is, of course, water vapour. If air be saturated with moisture, and while the pressure remains constant a reduction of temperature occur, some of the aqueous vapour is condensed, forming water. If, again, a non-saturated mixture of air and vapour be cooled down, at constant pressure, the point of saturation will be at length reached, and when this is attained condensation occurs. The temperature at which saturation of the air with vapour is reached is termed the "dew point." Now, throughout this cooling process, up to the time when condensation occurs, the vapour pressure will have remained unchanged, for both the gas and vapour, in the mixture, are subject to the laws of Boyle and of Charles, and the coefficient of expansion, a, is the same for each; hence whatever change is undergone by the total pressure must be equally undergone by each of the constituent pressures. But the total pressure remains unchanged, free communication with the external atmosphere being assumed, and, therefore, each of the constituent pressures also remains unchanged. In other words, the product of the volume and pressure of the mixture, divided by T, its absolute temperature, is constant, and the product of the volume and pressure of the water vapour, divided by T, is also constant. Expressing this in signs $\frac{VP}{T}$ is constant, and $\frac{VP^1}{T}$ is also constant. But as P is constant, $\frac{V}{T}$ must be constant, and hence P^1 is constant. Thus the actual vapour pressure in the air which is cooled down, remains throughout that which obtains when the dew point is reached. At this point the air is saturated, and the vapour pressure is the maximum pressure for that particular temperature. Hence the actual vapour pressure, in a portion of air, may be determined by ascertaining the temperature at which condensation occurs, and finding what vapour pressure corresponds to saturation of the air with vapour at that temperature.

The maximum pressure of vapour corresponding to different temperatures was first determined by Regnault, who constructed a table showing that in the case of water vapour, the maximum pressure varied from some 4·6 mm. of mercury at 0° C., up to some 148 mm. at 60° C., and to 760 mm. at 100° C. It will be noted that the maximum pressure at boiling point is the atmospheric pressure 760 mm.; a little consideration will make it clear why this should be so. The pressure on a rising bubble of vapour is, of course, the atmospheric pressure plus the weight of water above it; thus, if the bubble reach the surface it must still, on arriving there, have a vapour pressure equal to the pressure of the atmosphere. In other words, in order that bubbles of vapour may escape at the surface, the vapour pressure must be equal to atmospheric pressure; hence, also, a liquid may be said to be boiling when it gives off vapour of the same pressure as the atmosphere above it. The boiling point will be somewhat higher in the deeper layers of the water than it is at the surface; for this reason, in finding the fixed point of a thermometer, the instrument is plunged into the steam evolved from the water and not into the water itself.

Again, it will be clear that, at increasing heights above sea level, the boiling point will progressively become lower and lower, and given the boiling point, the atmospheric pressure and hence the height above sea level, can be determined by reference to a table, such as that constructed by Regnault, showing the maximum pressure of aqueous vapour corresponding to different temperatures.

In studying the condition of the air, with respect to its contained water vapour, it is important to know not so much the actual amount of vapour present, as the proportion which this actual amount bears to the quantity there would be if the air were saturated. This ratio is termed the "humidity," or sometimes, the "relative humidity." If the relative humidity be low, the air usually gives the sensation of dryness; if high, the air, as a rule, appears damp; and this remains true, although, in the former case, it may be found that the actual amount of vapour is considerable, or, in the latter case, that it is small.

Relative humidity may be defined as the ratio of the mass of vapour existing in a given space, to the amount which would saturate the space at the particular temperature under consideration.

Experience generally seems to show that in this country a relative humidity of 65 to 75 per cent. is most comfortable, but no hard and fast limit can be fixed for artificially heated rooms as the degree of relative humidity which should be aimed at will vary somewhat with the temperature.

The relative humidity can be determined by the use of the wet and dry bulb thermometer and tables constructed for the purpose. The best relative humidity is present when the difference between the wet and dry bulb thermometer is not less than 4° F. and not more than 5°. A simple practical rule for regulating the humidity of occupied rooms is suggested by M. H. Gordon who states that comfort may be secured by keeping the wet bulb of the thermometer below 60° F. Excessive dryness of the air has an irritating effect on the mucous membrane of the nose, throat and bronchi, excessive humidity on the other hand especially when accompanied by heat is enervating and depressing.

Hygrometers are instruments used for measuring the amount of moisture in the air. They belong to one of four classes—chemical hygrometers, and hygrometers of absorption, of condensation, and of evaporation. In the *chemical hygrometer* the amount of aqueous vapour is determined by drawing air, by means of an aspirator, through a system of U-tubes containing fragments of pumice soaked in sulphuric acid, and ascertaining the increase of weight which occurs. This method, although extremely accurate, is too laborious for ordinary application. The other three forms of hygrometer are as follows :—

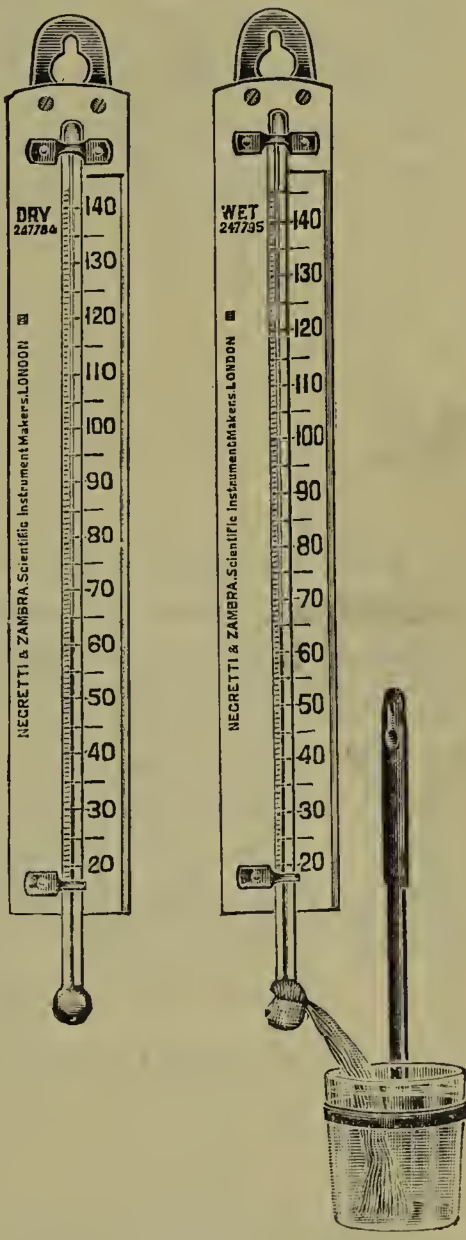
(i) *Absorption hygrometers*, the construction of which is based on the property possessed by organic substances of elongating on becoming moist, and contracting on drying. A band of human hair freed from fat by boiling with caustic alkali suitably supported and having a pen attached to the middle is often used to mark the relative humidity on a calibrated chart placed on a drum which is kept revolving by clockwork. The properties of the hair undergo slow changes and the instrument must be frequently set against the relative humidities determined by a wet and dry bulb thermometer.

(ii) *Dew point hygrometers* record the temperature at which condensation of vapour occurs. Dines' hygrometer has a chamber in which cold water can be made to circulate around the bulb of a thermometer. At the upper part of the chamber is a plate of black glass ; as soon as the cooling process reaches the point at which dew appears on the black glass, the thermometer is read, and the flow of cold water being then stopped, the thermometer is again read when the dew disappears. The mean of the two readings gives the dew point.

In Daniell's hygrometer cooling is effected by the evaporation of ether. The instrument consists of two globes, connected by a bent tube. One globe, made of black glass, contains a little ether and has a thermometer fixed in it; the bent tube contains, of course, ether vapour. The second globe is moistened externally with ether, the evaporation of which causes condensation of ether vapour in the globe, and this excites evaporation of the ether in the thermometer-containing-globe, with consequent lowering of temperature. The temperature recorded when dew is deposited on the black globe is observed, and that registered when the dew disappears is also noted; as before, the mean of these readings gives the dew point.

Regnault's hygrometer is an improved form of Daniell's hygrometer, in which evaporation of the ether is produced by drawing air through it by means of an aspirator. By this means the ether is kept in agitation, and uniformity of temperature is thus secured. Further, arrangement is made for the operator to observe the deposition of dew from a distance, and so the disturbing influence of his proximity to the instrument is eliminated. Again, a silver cap is substituted for the less sensitive black glass globe; furthermore, this hygrometer can be manipulated with alcohol, a considerable advantage when, as is the case in warm climates, the much more volatile ether can only with difficulty be employed.

(iii) The form of hygrometer which is commonly used in temperate climates is the "*wet and dry bulb*," Mason's hygrometer, or August's psychrometer, as it is called abroad. This instrument consists of two ordinary thermometers, one of which has its bulb covered with muslin, which dips into, or communicates by means of a wick or cotton with, a vessel containing distilled water. The dry bulb gives the temperature of the air, the wet bulb gives a somewhat lower reading, in correspondence with the amount of evaporation, and consequent lowering of temperature which takes place. If the air be saturated no evaporation can occur, and the reading of the two bulbs is the same, though it may be noted that, under the circumstances named, the wet bulb reading may very slightly exceed that of the dry bulb,


DRY
247784
WET
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NEGRETTI & ZAMBRA. Scientific Instrument Makers. LONDON
NEGRETTI & ZAMBRA. Scientific Instrument Makers. LONDON
140
130
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FIG. 4.
Wet and Dry Bulb Thermometer.

inasmuch as the former is to some extent protected from radiation by its covering of muslin. The difference in the two readings ordinarily ranges from 1° or 2° in winter, to 6° or 8° in summer. In using the instrument there should be no interference with access of air to the wet bulb, the vessel containing water should be small and placed at a little distance from the bulb, the muslin must be kept moist, and drops must not be allowed to fall from the bottom of the bulb. When frost prevails the wick no longer acts, and the bulb is then brushed over with water, which must be allowed time to freeze before the reading of the ice-covered bulb is taken.

Having noted the readings of the two thermometers the dew point is ascertained, either by the use of Glaisher's tables or by the following formula, known as Professor Apjohn's formula :—

$$F = f^1 - \frac{t - t^1}{87}$$

for which must be substituted when the wet bulb is frozen—

$$F = f^1 - \frac{t - t^1}{96}$$

where t and t^1 are the dry and wet bulb readings, f^1 is the vapour tension corresponding to t^1, and F is the vapour tension at the dew point.

For the application of Apjohn's formula a table of vapour tensions must in any case be used, and in practice, having ascertained the dry and wet bulb temperatures, both the dew point, and, for all ordinary readings, the relative humidity, can be obtained without calculation, by the use of Glaisher's tables.[1] In these tables a series of factors, Glaisher's factors, is given for each reading of the dry bulb thermometer. The dew point is determined by subtracting the product obtained by multiplying the dry bulb factor and the difference between the wet and dry bulb temperatures, from the temperature of the dry bulb. This may be shortly expressed in the formula :—

$t - D\ (t - t^1)$ where D = Glaisher's factor
t = dry bulb temperature
t^1 = wet bulb temperature.

The dew point being determined, the weight of a cubic foot of vapour at the dew point can be read off in the tables and the relative humidity, *i.e.*,

$$\frac{\text{Weight of a cubic foot of vapour at the dew point}}{\text{Weight of a cubic foot of vapour at the dry bulb temperature}} \times 100,$$

calculated with the aid of a table giving the weights of a cubic foot of vapour at each temperature. In practice, as has been said, it is usually taken directly from the set of tables, which supplies the relative humidities for all ordinary readings likely to be recorded.

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[1] The Meteorological Office has recently prepared a set of hygrometric tables for the computation of relative humidity, vapour pressure and dewpoint from readings of dry- and wet-bulb thermometers exposed in Stevenson's screens; these tables are based on Regnault's formula and are intended to replace Glaisher's tables.

The following example may be given of the simple calculation necessary supposing the dry and wet bulb temperatures known, while a table giving Glaisher's factors and a table of vapour tensions are alone available.

Example.—The dry and wet bulb readings are 60° F. and 55° F., what is the relative humidity ?

$$\begin{aligned}\text{The dew point} &= 60 - 5\,D\\ &= 60 - 5 \times 1{\cdot}88 \text{ (from the table of factors)}\\ &= 50{\cdot}6^\circ\text{ F.}\end{aligned}$$

The weight of a given volume of vapour varies as its pressure, elastic force or tension. Hence the relative humidity, which is equal to—

$$\frac{\text{Weight of a cubic foot of vapour at the dew point}}{\text{Weight of a cubic foot of vapour at the dry bulb temperature}} \times 100,$$

is in this case $= \left.\dfrac{\text{Tension at } 50{\cdot}6^\circ\text{ F.}}{\text{Tension at } 60^\circ\text{ F.}} \times 100, \right\}$ which from the table of tensions,

$$= \frac{{\cdot}369}{{\cdot}518} \times 100 = 70{\cdot}1 \text{ per cent.}$$

It may be required, given the necessary data, to determine the weight of a certain volume of moist air.

Example.—Find the weight of a cubic foot of moist air, containing 70 per cent. of moisture, at 60° F., under 29·92 inches barometric pressure.

The mass may be regarded as made up of two parts. A cubic foot of dry air at 60° F. under the existing pressure, less the tension of the vapour present; and a cubic foot of vapour at 60° F., and under a pressure equal to the vapour pressure at the dew point.

The pressure at the dew point will be $\frac{7}{10}$ths of the maximum tension of vapour at 60° F. This latter pressure = ·518 in. of mercury.

∴ The vapour tension of the moist air = ·362 inch.

Now a cubic foot of dry air, at 60° F. and 29·92 inches pressure, weighs 536·3 grains, therefore at pressure 29·92 – ·362, *i.e.*, 29·558 inches, it will weigh $\frac{29{\cdot}558}{29{\cdot}92} \times 536{\cdot}3$ grains, or 529·81 grains.

The weight of a cubic foot of vapour at 60° F. is 5·77 grains if the vapour is at maximum pressure, and therefore the humidity in the present case being 70 per cent., the weight of the cubic foot of vapour = 4·039 grains.

Hence the weight of the cubic foot of moist air = 533·849.

It will be noted that this weight is less than that of a cubic foot of dry air at 60° F. and 29·92 inches pressure, and, generally, when water evaporates into dry air the resulting mixture has less weight, volume for volume, than the original dry air.

Diffusion of Gases—If communication be made between two receivers containing different gases they diffuse one into the other. The rate of diffusion depends upon the densities, and if it be tested by allowing different gases to diffuse through a porous septum, it will be found to vary inversely as the square roots of the densities of the gases. This is called the law of Graham. Thus, if oxygen and hydrogen diffuse, one into the other, the densities being as 16 to 1, the rates of diffusion will be as 1 to 4, four parts of hydrogen diffusing into the oxygen, for each part of oxygen that diffuses into the hydrogen. The process of interchange continues as long as the mixtures remain dissimilar. Thus, if an upper glass globe containing hydrogen be placed in communication with a lower glass globe containing carbon dioxide, which is twenty-two times as dense, the two gases will ultimately become uniformly mixed, the lighter hydrogen diffusing downwards and the heavier carbonic acid diffusing upwards. It is this process of diffusion which causes the atmosphere to remain of uniform composition, by leading to the distribution, throughout the general body of air, of any special constituent gas, which may be produced in excess at a given point.

Another important cause of interchange is the fact that movement is set up when constituent portions of the atmosphere, of like composition but of differing densities, come into communication with one another. Differences of temperature, by producing alterations of density, are largely operative in determining interchange of air.

If liquid escape from an opening in the side of a vessel, the velocity becomes greater when the *head* of liquid, *i.e.*, the depth of the opening below the surface, is increased. Torricelli's theorem is to the effect that the velocity of efflux is equal to the velocity which would be attained by a body falling from the upper surface of the liquid to the opening, or, if h be the height of the surface above the orifice,

$$V = \sqrt{2gh}$$

If air flows into a vacuum its velocity will be $\sqrt{2gh}$, where h represents the height of the imaginary column of air, of the same density as the effluent air, which would be required to produce the atmospheric pressure, and g the acceleration of gravity, *viz.*, thirty two feet per second at latitude 45°. This imaginary column would have to counterbalance 760 mm. of mercury, and it may therefore be calculated to be about 5 miles, or 26,400 feet high. Hence V will be found to be about 1,300 feet per second. If the air diffuse, not into a vacuum, but into other air at pressure corresponding to a height h^1, the formula becomes:

$$V^2 = 2g(h - h^1).$$

This rule, the rule of Montgolfier, as it is sometimes called, may be applied to the movement of a column of air in a chimney. Within the chimney is a column of heated air, while outside there is a column of colder air of equal height; the pressure at the top of these columns, being the barometric pressure and alike in both cases, may be neglected. Air expands $\frac{1}{273}$rd of its volume for each degree Centigrade, and this proportion corresponds to $\frac{1}{491}$, or approximately ·002, for each degree Fahrenheit. If then h be taken as the height of the chimney, h^1 is determined by finding what would be the height of the column of heated air, if it were reduced to the same density as the outside air; $h - h^1$ will then give the difference of heights upon which the movement depends.

If t and t^1 be the temperatures of the inner and outer columns, $1 + (t - t^1) \times {\cdot}002$ represents approximately the volume to which one volume at t^1 will have expanded at t.

$$\therefore h^1 = \frac{h}{1 + {\cdot}002\,(t - t^1)}$$

and

$$V = \sqrt{2gh\left[1 - \frac{1}{1 + {\cdot}002\,(t - t^1)}\right]}$$

Thus, if the chimney be 30 feet high and the difference of temperature 20° F.

$$V = \sqrt{2 \times 32 \times 30\,\frac{{\cdot}002 \times 20}{1 + {\cdot}002 \times 20}}$$

$$= \sqrt{2 \times 32 \times 30\,\frac{{\cdot}04}{1{\cdot}04}} = \sqrt{\frac{2 \times 32 \times 30}{26}} = \left\{\begin{array}{l}9{\cdot}5 \text{ ft.}\\ \text{per sec.}\\ \text{nearly.}\end{array}\right.$$

In practice the results obtained in the manner just indicated are much too high; allowance has to be made for friction (which varies directly as the length of the chimney and the square of the velocity, and for similar sections inversely as their diameters) and for angles, etc., to say nothing of soot and dirt.

Heat is distributed through space by conduction, by convection, and by radiation. Conduction of heat is chiefly manifested in solid substances, of which some—certain metals, for example—are very good conductors of heat, while others, such as glass, are bad conductors. Wool and furs, and silk, are bad conductors, and hence their use for purposes of clothing, as they serve to prevent the heat of the body being dissipated. In the same way woollen materials may be used to keep substances cold, as for example, when a block of ice is wrapped in flannel. Moreover, wool and, to a less extent, silk possess the capacity of absorbing moisture. If a woollen garment be put on after exercise, the vapour from the surface of the body becomes condensed in the wool, imparting to it the heat rendered latent when vaporisation occurred. The garment therefore at once feels warm, and the tenacity with which it holds the moisture prevents re-evaporation and chilling; linen and cotton are better conductors of heat than wool, and do not possess the same hygroscopic property; when they are rendered damp by perspiration, evaporation proceeds rapidly and chilling of the body results.

In considering the relative conductivity of wool, cotton, linen and silk, the conductivity of the raw material must not be confused with that of the same material made up into a fabric suitable for clothing. In the latter case the conductivity to heat is much lessened by the air-containing spaces in the woven fabric. The ordinary atmosphere is the best and most universal non-conductor we have, and the heat retaining power of most materials is in direct proportion to the amount of air they imprison in their interstices. Hence the warmth of eiderdown quilts, feather beds, and thick blankets. Leather overcoats which are practically non-porous, are used in flying and motoring to prevent the air contained in the clothes worn underneath from being forcibly removed by the strong currents generated when moving rapidly through the atmosphere.

That raw material has a certain amount of inherent non-conductivity is shown by experiments which prove that if the conductivity of air be taken as 1, that of wool fibre is 6, of silk 19, and cotton and linen 30. Garments therefore of the same thickness and mode of weaving made from these fibres will still retain the same relative conductivity, while the absolute conductivity as compared with air, will differ largely according to the mode of weaving and thickness.

There are, broadly speaking, two methods of weaving used for undergarments, viz., that by web and woof and stockinette. As examples of the former may be mentioned ordinary flannel, calico and linen, and of the latter the ordinary woollen and cotton " vests " worn by men.

Stockinette has the advantage of clinging closely to the body, and if the meshes are of medium size, they not only contain a considerable amount of air, but allow of free interchange from within outwards, and *vice versâ*. It is obvious that if the meshes are too open, the heat retaining power may be greatly lessened by the too free interchange of air. For those who live in the tropics, and where the body perspires freely, thin flannel would appear to be best; for temperate and cold climates stockinette has many advantages, especially if made of wool. All intermediate grades between wool and cotton can be attained by admixture of each of these in the fabric in varying proportion.

Where price is a consideration a very warm material can be made from cotton, known as flannelette, but when heated it is liable to burst into flames suddenly; there are now many kinds on the market in which this drawback has been removed.

Liquids and gases as a rule are very poor conductors, but heat may be freely distributed in them by convection currents, which convey the heated particles from one part of the liquid or gas to another. The transmission of heat by radiation, and, of course, mainly by solar radiation, is the great cause of the maintenance of temperature at the earth's surface; some of the heat so transmitted is again radiated by the earth into space. The atmosphere (and in particular the aqueous vapour of the air) plays an important part in checking excessive loss of heat from the earth by radiation, it also absorbs and intercepts heat radiated from the sun. The heat radiated by bodies is absorbed, transmitted, or reflected by other bodies just as light is; indeed, light rays constitute, as it were, a particular case of radiation, corresponding as they do to the special form of radiated energy which the eye is adapted to perceive; the rays which are invisible are sometimes called dark rays. Dry air absorbs very little of the heat radiated through it; moist air absorbs a good deal, thus becoming itself heated. The heating effects observed, during exposure to the sun's rays, in the dry air of places at high altitudes in Switzerland, illustrate on the one hand the small extent of its interference with solar radiation; while, on the other hand, the contrast afforded between the temperature on a clouded and on a clear night in winter, shows how large a part the aqueous vapour of the atmosphere when condensed in clouds may play in preventing loss of the earth's heat by natural radiation. Different substances require different amounts of heat in order to produce in them increase of temperature to a like extent. Water absorbs more heat, for a given increase of temperature, than most other substances. If the quantity of heat required to raise one gramme of water one degree from 15° to 16° C. be taken as the unit,[1] the amount required to raise an equal weight of any other substance one degree Centigrade is termed the *specific heat* of that substance. As a rule the specific heat of solids is greater at a high than at a low temperature, hence the reference to ice-cold water, *i.e.*, to water at a particular temperature, as a standard.

Latent heat is the heat absorbed or rendered latent when bodies pass from the solid to the liquid, or from the liquid to the gaseous condition without indicating any change of heat by the thermometer. The number of calories required to convert a gramme of ice at 0° C. into a gramme of water at 0° C. is 80 and this is therefore the latent heat of water and is the number of calories required to raise one gramme of water from 0° C. to 80° C. The latent heat of steam at 100° C. is found to be 537 units, in other words, to convert a gramme of water at 100° C. into steam at 100° C. requires 537 calories.

In connection with the subject of warming by convection, certain points should be noted. In the process of cooling, the surface particles of water, as their temperature is lowered, become more dense and descend, being replaced by particles from beneath. By convection the whole body of water is thus gradually cooled, but a remarkable fact needs to be borne in mind. The maximum density of water is attained at 4° C., and when that point is reached the water-particles cease to become more dense, as their temperature is further lowered down to 0° C. Thus, as cooling proceeds, ice is formed at the top of the water.

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[1] This unit is also known as the calorie.

Convection currents in air must also be particularly referred to. Differences of temperature of masses of air, by producing differences of pressure, disturb the equilibrium of the atmosphere, and the result is wind. The force of wind is estimated by instruments called anemometers ; there are two varieties of these, "pressure" and "velocity" anemometers. The simplest form of pressure anemometer consists of a sheet of metal suspended by its superior border, and a rough indication of the pressure of the wind is afforded by observing the angle through which the sheet is deflected by that pressure. In Lind's anemometer the force of the wind is measured by observing the height to which a column of water is raised in one arm of a U-shaped tube, when the water in the other arm is in communication with an opening turned to the wind. The pressure anemometers of Osler and Cator are somewhat more complicated instruments, in which resistance is furnished, in the one case by springs, in the other by a series of levers, and the pressure recorded is marked by a travelling pencil upon a sheet of paper.

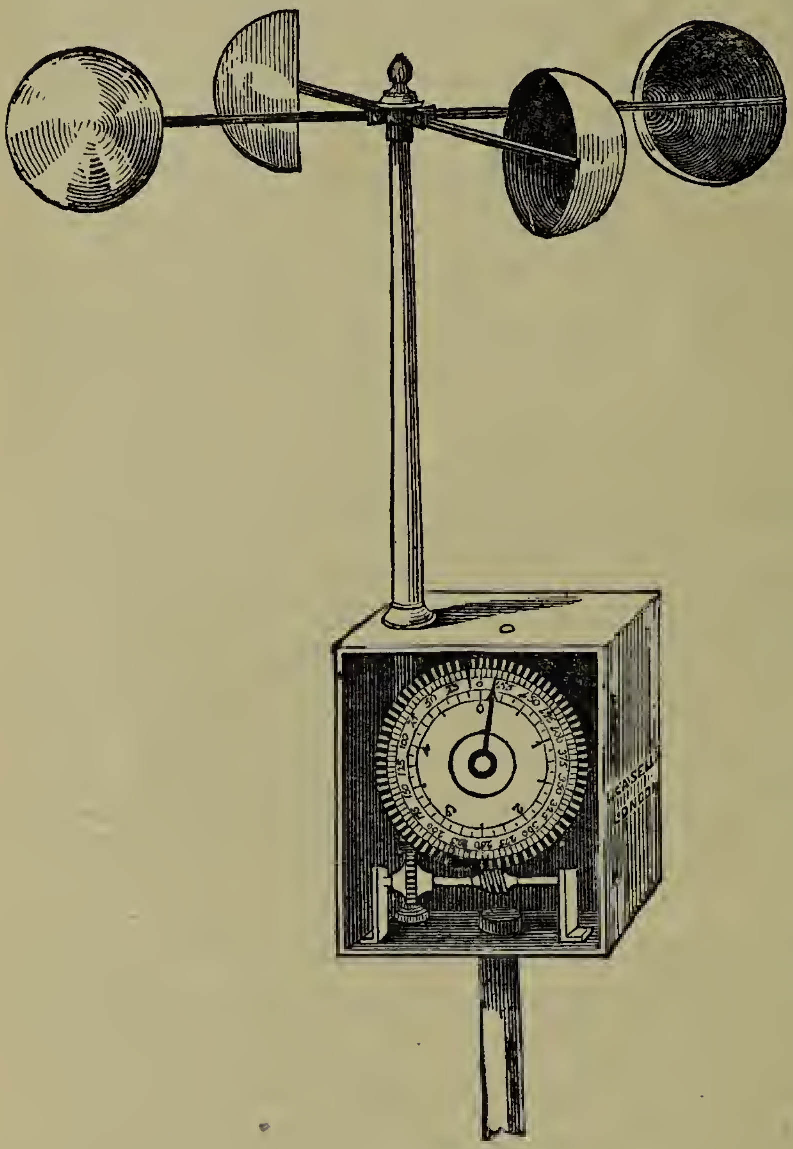


Fig. 5.—Robinson's Anemometer.

The form of anemometer usually employed is Robinson's velocity anemometer. In the case of this instrument the velocity of the wind is determined by noting the rate at which four hemispherical cups rotate around a vertical axis, about which they can revolve in a horizontal plane. The wind exerts greater force upon the hollow surfaces of the cups than upon their rounded surfaces, rotation therefore occurs, and the stronger the wind the faster the rotation. It was supposed originally by Robinson that the rate of rotation was constant for varying dimensions of the parts of the instrument, and that the cups moved with about one-third of the velocity of the wind. It is now known that this is not strictly correct; roughly speaking, however, the velocity of the wind may be taken as about 2½ times the velocity of the cups, when the instrument as ordinarily constructed, with cups 9 inches in diameter, on arms 24 inches in length, is employed. Allowance should be made for friction in the case of low velocities, and a good deal depends upon the position, in relation to neighbouring buildings, in which the instrument is placed. This should if possible be above surrounding buildings and as far away as possible from them.

W. H. Dines has invented an instrument known as the "tube (or pressure) anemometer" for making a continuous record of the velocity of the wind. It consists of two parts, the "head" and the "recording apparatus." The head is mounted on a pole 40 or 50 feet high; its upper part, which consists of a horizontal tube open at one end, is free to rotate, the open end being kept towards the wind by a vane at the other end. As the wind blows into the open end of the tube the pressure it creates is communicated by means of a flexible tube to the recording apparatus at the base of the pole. The short vertical tube on which the vane rotates is surrounded by an outer tube having four rings of small holes. The wind blowing over one of these produces a diminution of pressure in the space between the two tubes and this extracts air from the upper part of the cylinder of the recording apparatus to which the tube is connected by a second flexible tube.

The recording apparatus consists of a large cylinder partly filled with water; inside this is a conical shaped float the narrow end of which is truncated, open, and directed downwards while the broad end contains air and floats above the water. The pressure tube communicates with the air in the upper end of the float. Any increase of pressure causes the float to rise and in doing so it pushes up a rod which records by means of a pen all movements on a revolving drum. The upward movement of the float is assisted by the aspirating effect of the wind on the small hole above mentioned. This anemometer has been adapted to keep a simultaneous record of the direction as well as of the velocity of the wind.

The degrees of intensity of wind are often expressed by reference to what is known as Beaufort's scale, *i.e.*, to the standards laid down by Sir F. Beaufort early in the last century, and based mainly upon the relation of wind pressure to the amount of sail carried by the fishing smack of that time. There are 13 degrees of force on this scale beginning with 0, which corresponds to "calm," *i.e.*, to a velocity not exceeding three miles per hour: upon this follow the degrees termed 1 to 6, and referred to as light air, and light, gentle, moderate, fresh and strong breeze: then the degrees 7 to 10, moderate, fresh, strong and whole gale, and 11 "storm" (seventy-five miles per hour) supervene, and finally the degree 12 corresponds to "hurricane" (ninety miles per hour).

This scale gives good results at the many meteorological stations without any special apparatus for measuring the speed of wind.

WEATHER FORECASTS

Of late years much attention has been directed to this subject. As long as observation was limited to the fluctuations of the barometer at a particular place but little progress was made. Certain connections between rise and fall of the barometer, and the occurrence of rain and wind were noted, and rules were formulated as to the significance of sudden and sustained alterations of barometric pressure under varying conditions. With the introduction of communication by telegraph, however, a great change was brought about, and the synoptic chart method has now assumed special importance in connection with weather prognostications.

In the weather reports published in the daily press it is usual to give the atmospheric pressure in millibars and inches of the mercury barometer. This dual notation is for the convenience of those accustomed to the latter method and will no doubt be later abandoned in favour of the millibar which is the more useful for international meteorology. The fundamental pressure unit of the metric system is 1 dyne per square centimetre, the millibar consists of 1,000 of these. This is very convenient especially as the atmospheric pressure near the earth's surface is about 1,000 millibars (or 1 bar) and this can be made the dividing line between high and low pressure, the equivalent in inches being a column of mercury 29·531 inches high (750·1 mm.) at 32° F. (0° C.) under conditions of gravitation existing in latitude 45° N. or S.

If the barometric pressures at one and the same moment of time be ascertained at various stations over a considerable area, it is possible to construct *isobars*, *i.e.*, lines connecting all the points at which the same pressure prevails; these isobars present certain characteristic shapes, and from their configuration a good deal can be learnt.

There are two primary and five secondary types of grouping of isobars which have been specially described, and which are illustrated in Fig. 6. Just below its centre there will be found an area in which the isobars form closed curves, and in which the pressure, measured in tenths of an inch, increases on proceeding from without inwards; such an arrangement of isobars constitutes an *anticyclone* or high pressure area.

On either side of the central anticyclone of the figure are seen the edges of two other anticyclones; the areas of comparatively low pressure intervening between the anticyclones are termed, from the analogy of a pass between two mountains, *cols*. If the isobars, instead of enclosing an area of high, enclose one of low pressure, the arrangement constitutes a *cyclone* (see the upper part of Fig. 7, on the right hand side). The cyclone and anticyclone are the two primary types already referred to: the secondary types include the *col*; the *secondary depression or cyclone*, in which an area of low pressure is enclosed, as it were, in a loop without being completely detached; the V-*shaped depression*, in which a low pressure area is pushed in, so to speak, between high pressure areas; the *wedge*, in which a high pressure area projects wedge-like between two neighbouring cyclones; and, finally, *straight isobars*, in which the lines of equal barometric pressure form practically parallel straight lines.

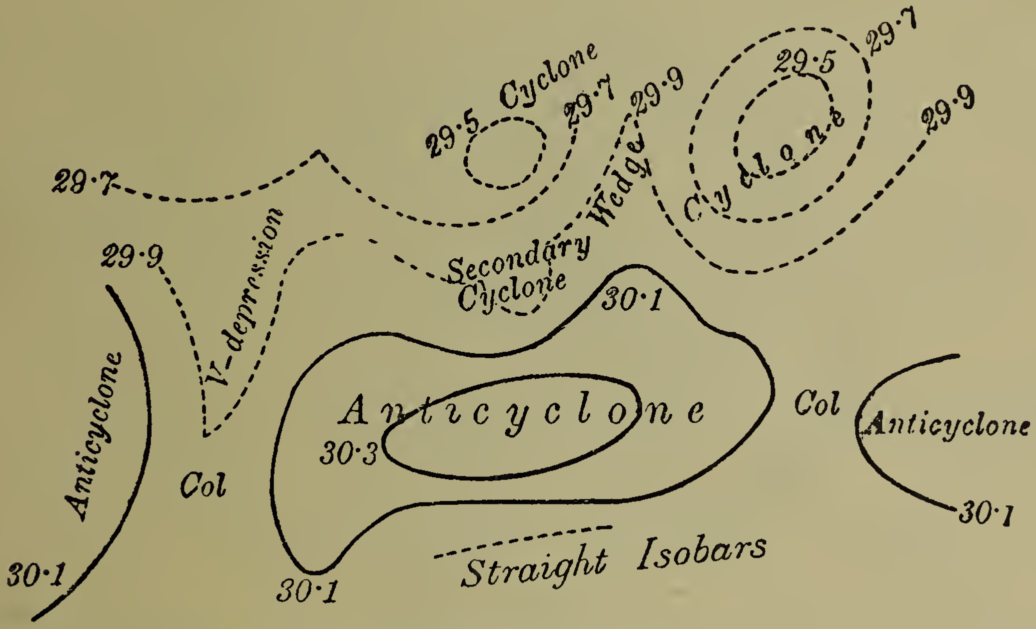


FIG. 6.—Diagrammatic representation of pressure distribution, over the North Atlantic and parts of Europe and the United States, on February 27, 1865.

Two further points require to be specially noted concerning the arrangement of the isobars. In the first place, the force of the wind varies with their closeness. If the barometric gradient be steep, *i.e.*, if the isobars, for example, corresponding to differences of pressure of 5 millibars, are comparatively close to one another, the wind will be proportionately strong, and *vice versâ*. Again, from the arrangement of the isobars the direction of the wind can be deduced by "Buys Ballot's law," which is to the effect that, on standing "back to the wind," the lowest pressure lies to the left and in front. A little consideration will make it clear therefore that, in a cyclone, the wind blows spirally inwards, towards the area of low pressure; and if wind arrows be marked all round such an area, their direction will change, on proceeding round the circle, in a manner opposed to that of the movement of the hands of a clock. In an anticyclone, on the other hand, the wind blows spirally outwards, the arrows changing in a manner corresponding to the movement of the hands of a clock.

Barometric "depressions" or cyclones are the main factors in determining weather conditions in such a region as north-west Europe. When a depression is present on the current synoptic chart the forecaster must endeavour to predict the direction of its further travel. This is effected by the application of several principles. If the depression has already followed a steady course, strong reasons will be needed to predict a change of direction. The changes of barometric pressure must also be taken into account, especially those in the three hours immediately preceding the fixed hour of observation at the station contributing to the synoptic chart, when it will generally be found that the depression travels towards the place of greatest fall.

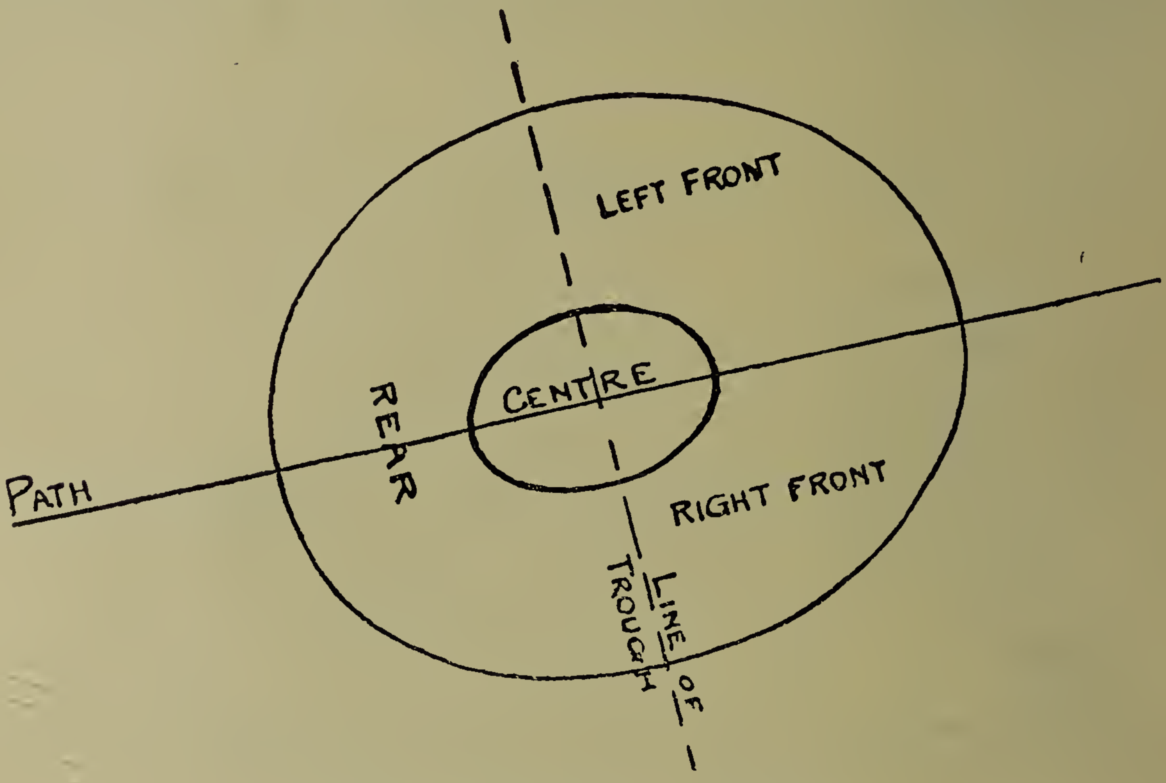
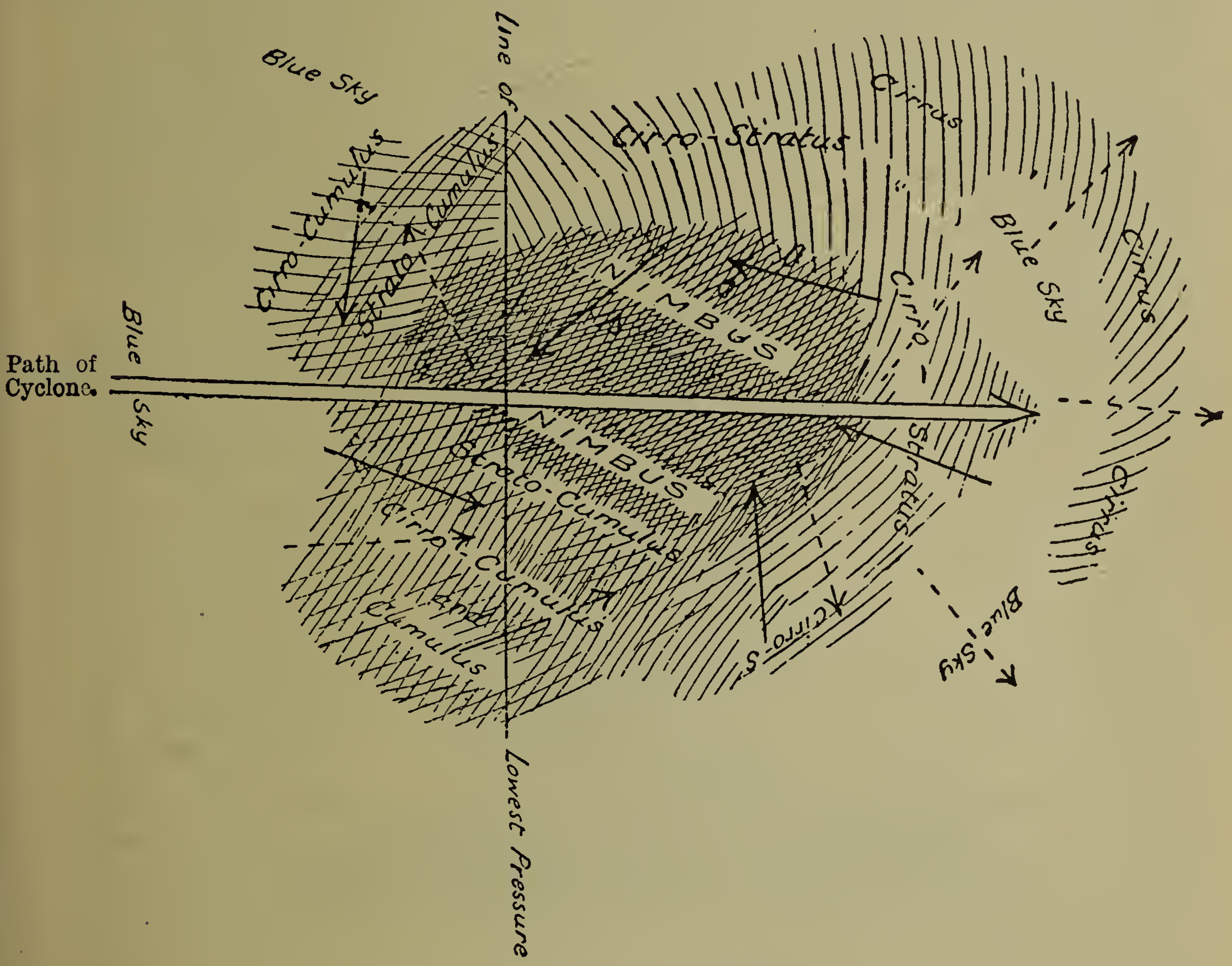


FIG. 7—Nomenclature of a Depression.

A study of the wind directions at the various stations is of much value in forecasting. The backing of the wind, *i.e.*, its changing in an anti-clockwise direction, is the sign of the coming of a depression towards the station showing the "backing." The meteorological observations taken on the west coast of Ireland have proved to be of much service as depressions generally approach this country from the Atlantic. The centre of a depression seems to prefer to travel over water rather than over land; when travelling over land the centre apparently favours the lowlands.

Generally speaking the centre travels from a westerly point eastwards with a tendency to north, so that a large number move from a south-west point to a north-east point. The area of the centre is covered with nimbus (rain) clouds which are generally the source of fairly continuous rain which falls in or near the left front of the depression. As the front of the cyclone approaches, the ordinary signs of rain usually appear, halos around moon or sun, capped hills, etc.; the rain then falls in gradually increasing amount, until the "trough" or line of lowest pressure passes, when squalls of wind and "clearing showers" are observed; then patches of blue sky follow, and the weather clears. Again, differences are observed according to whether the area of lowest pressure passes directly over,



——————→ Wind direction at the earth's surface.
- - - - - - → Wind direction in the region of the cirrus cloud.

FIG. 8.—Distribution of Cloud in a Depression.

or a little to the north or south of the place of observation. Broadly speaking, however, the front of the cyclone corresponds with dirty, gloomy sky, the clouds being of strato-cumulus type, and with warmth and a feeling of oppression in the air; while the rear of the cyclone corresponds with a sky of cumulus type, with cold, and a brisk feeling in the air. The area of lowest pressure tends to pass, as a rule, to the north of England, and this fact explains how it comes about that in this country the wind "veers," or changes with the sun, more often than it "backs," or changes in the contrary direction.

Anticyclones, unlike cyclones, tend to remain stationary for several days; in summer they usually bring fine, calm weather with much sunshine and a high temperature during the day, while at night the skies are clear but there is much ground mist and fog; in winter according to the type of anticyclone the weather may be fine during the day, but very cold with frost or fog during the night, or the sky may be persistently covered by low cloud sheets causing "anticyclonic gloom." Anticyclones are comparatively isolated and inert, taking little part in the circulation of air going round them; they are not necessarily areas of fine balmy weather for almost any kind of weather except violent storms may be associated with them.

On development of the col in winter, fogs and mists often occur, and in warm weather thunderstorms. Secondary depressions and V-shaped depressions correspond to weather of more or less disturbed character. The wedge in these latitudes usually points northwards; it is associated with a temporary period of fine weather, and is usually followed by cyclonic disturbance.

Almost any type of weather may accompany straight isobars. When isobars run from south-west to north-east over the British Isles with the centre of the big depression of which the isobars form a part somewhere in the Icelandic region, the weather varies from fair or fine to overcast with showers or steady rainfall, and following the Buys-Ballot law the winds will be generally west and south-west.

The general distribution of atmospheric pressure over the northern hemisphere is as follows:—In the tropics there is a high pressure belt which rises here and there into anticyclonic elevations One of these elevations, the Atlantic anticyclone, is as a rule found over the central Atlantic. To the north and south of the tropical high pressure belt are regions of comparatively low pressure; an equatorial area lies to the south, while on the north low pressure generally prevails, but high pressure areas may be developed from time to time. "Trade winds" are the north-east and east winds on the southern side of the Atlantic anticyclone. There are corresponding south-east trade winds on the north side of a great anticyclone in the south Atlantic; between these regions of wind is the calm equatorial zone known to sailors as "the doldrums."

Four general types of weather have been described as occurring in western Europe: in these the prevailing winds are from the south, west, north, and east respectively. In the first, the southerly type, an anticyclone lies to the south or south-east of Great Britain, and there is a low pressure area over the north Atlantic: from this area cyclones originate, and travel eastwards towards the high pressure area; on nearing it they die out and disappear, or they pass round it in a north-easterly direction. This southerly type is most common in winter time, but occurs at all periods of the year. In the westerly type, a high pressure area exists south of Great Britain; cyclones originate in the Atlantic, and travel mainly east and south-east. When their areas of lowest pressure pass so far south as to travel over this country, the severe storms which usually occur in spring and autumn are experienced. In the northerly type, there is high pressure over the Atlantic to the west and north-west of Great Britain; cyclones originate on the north or east side of this anticyclone, and travel east or south-east. This type is rare in the autumn months. In the easterly type there is high pressure over Scandinavia, and cyclones originate in the north Atlantic and pass south-east, between the Scandinavian high pressure area and the Atlantic anticyclone, across the col which connects these two high pressure areas. These cyclones may be arrested as they approach the high pressure region, and thus fail to pass over Europe. Sometimes cyclones originate over southern Europe, to the south of the Scandinavian anticyclone, and travel eastwards or even westwards.

When we speak of the weather of any particular place we mean the sum of the meteorological conditions at any given time; the climate, on the other hand, is the average weather and as with all averages, the longest period of weather averages gives the most reliable idea of the climate.

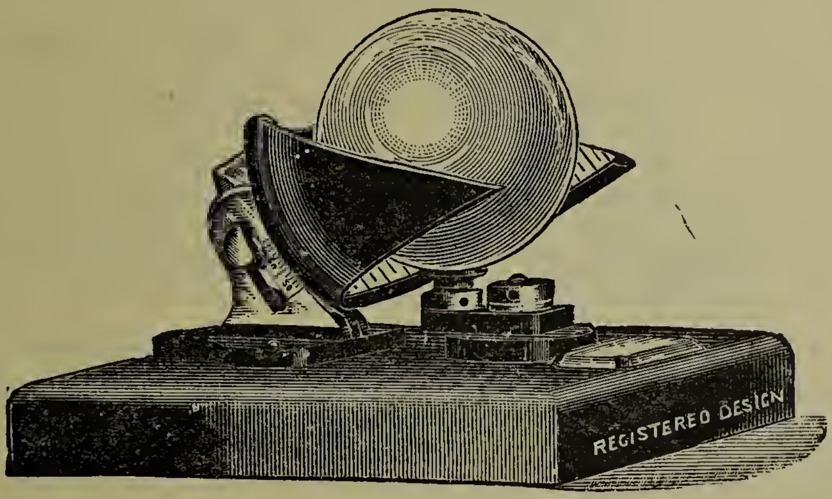


FIG. 9.—Campbell-Stokes Sunshine Recorder.

Records are kept in many health resorts of the daily amount of sunshine; to ascertain this the Campbell-Stokes sunshine recorder is most frequently used. A large spherical lens exposed in a high open situation concentrates the rays of the sun on a graduated strip of specially prepared card placed at the proper focal length. When the sun shines a charred line is burnt inside the card; the total number of hours corresponding to the charred portions can be ascertained.

CLIMATE

The climate of any place is determined by the temperature and moisture of the air, these in turn are often modified by the prevailing winds which bring air with the temperature and moisture of that of the regions through which they have passed.

The temperature is mainly influenced by the latitude being highest when the sun is vertically overhead, and its effect is concentrated upon a small surface, as at the Equator. But other climatic influences have disturbing effects, hence the zones should be located by lines drawn through places with the same mean annual temperature (isothermal lines). Hot climates are those between the Equator and isotherm 77° F., warm between isotherms 77° and 59° F.; temperate between 59° and 41° F.; cold between 41° and 23° F. and polar between 23° and 5° F.

Maritime (marine), continental and mountain climates have been further distinguished.

In hot and warm climates there are usually well-defined dry and wet seasons, and the rainfall during the latter may be very considerable in amount.

A group of illnesses especially caused by the heat of hot climates is comprised in the term "heat stroke," which includes the non-febrile heat exhaustion, a severe form of fainting fit which, however, rarely ends in death. The pyrexial conditions include heat cramp, the condition chiefly seen among ship's firemen in the tropics and the more serious thermic fever. High relative humidity of the air (which checks cutaneous perspiration) and alcoholism are very potent factors in providing these conditions.

Temperate climates are usually met with between 35° and 50° of latitude, while between 50° of latitude and the poles cold and polar climates prevail.

Owing to the absence of intense heat or intense cold the temperate climate causes no great continued strain in any one set of organs and is in consequence the healthiest of all. Of the diseases which occur in temperate climates rheumatism, respiratory affections, phthisis, scarlet fever, diphtheria, and measles are especially destructive.

After sunset the land cools by radiation more rapidly than the sea, the air lying over the sea being warmer than the air over the land rises and expands and produces a breeze from off the land. This effect is most marked on small islands and at places on the seashore.

In continental climates the day is very warm and the night very cool, the summer hot and the winter cold. In this country the climate is typically maritime, being greatly influenced by the encompassing sea, and by the Gulf Stream. This last-named stream causes the lines of equal temperature, the "isotherms" of the north Atlantic, to run from south-west to north-east, and thus the winter of these islands is far less severe than that of Labrador, which is in about the same latitude. The influence of the Gulf Stream is especially marked upon the winter climate of this country, when the power of the sun is least felt. In August the isotherms (the dotted lines of Fig. 10) only deviate slightly from an east-and-west direction; but in January the isotherms (the black lines of the figure) immediately over Great Britain are markedly deflected, and run from north-west to south-east, and this fact accounts for the mildness of the winter in Cornwall, or even Dublin, as compared with that of London and Edinburgh. The marine influence exerted upon the English climate accounts for the absence of extremes of heat and cold, the prevalence of moist atmospheres, and the comparative lack of sunshine. The chief diseases associated with this form of climate are lung affections and those forms of "rheumatism" which are influenced by humidity and weather changes.

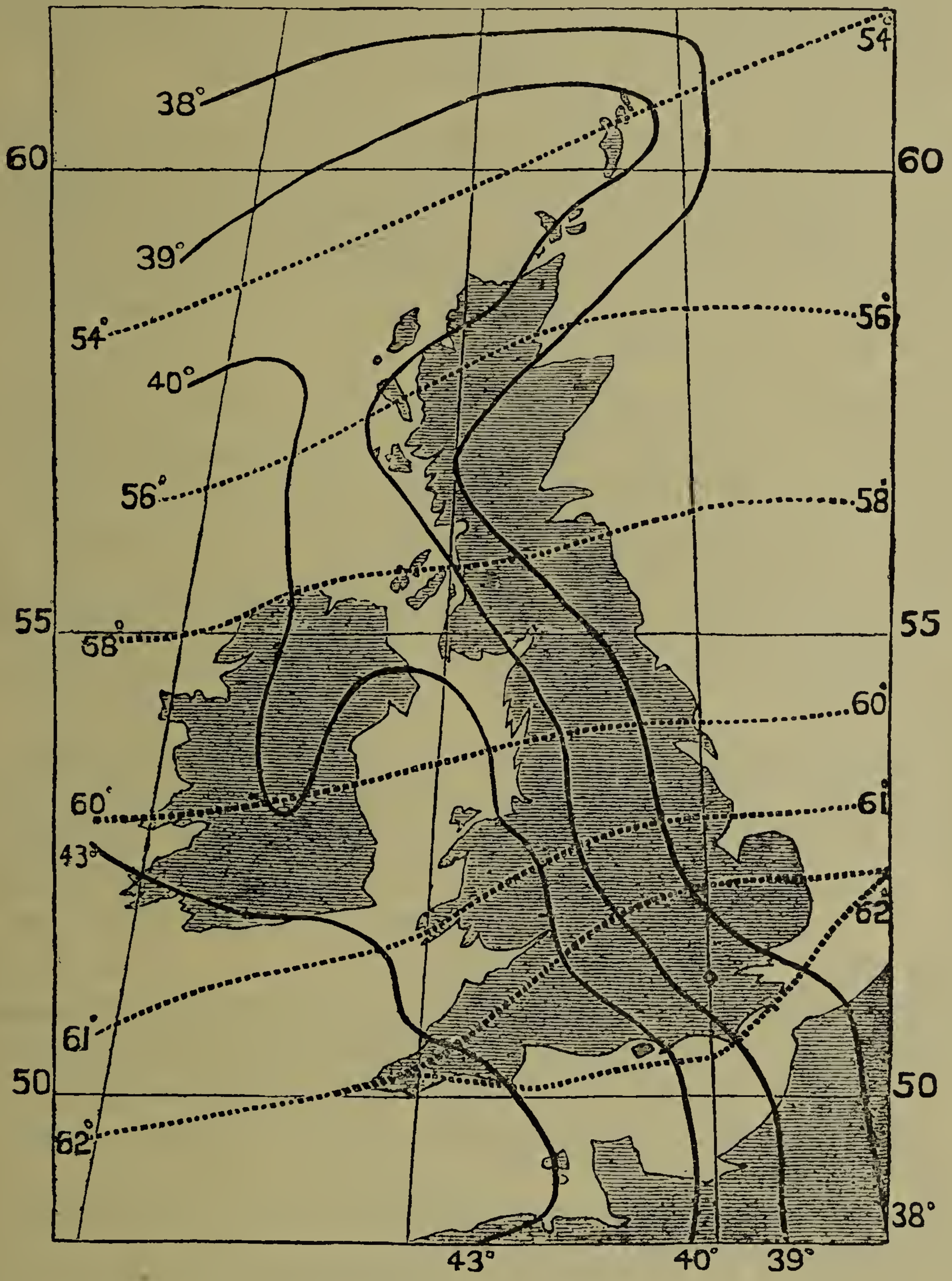


Fig. 10.—Isothermal lines of Great Britain. Dotted lines (August). Continuous black line (January).

The equability of the maritime climate is due to water absorbing heat slowly and retaining it much longer than land. The seasonal range of temperature is lessened by the direction of the winds. In summer a wind passing from the surface of the colder sea cools the land, in winter a warm sea breeze heats the land. Day sea breezes and night land breezes lessen the daily range of temperature. On a warm and sunny day the land, and consequently the air lying above it, is more rapidly heated than the sea, the air over the land expands and rises and a cool breeze flows in from the sea.

The inhabitants of cold and polar climates possess a vigorous constitution, great muscular development, active digestive functions but sluggish nervous powers. Although intense cold throws a greater strain on the lungs and kidneys the natives generally succeed in maintaining health, and live to old age, presenting few diseases referable to climatic influences. But they are subject to snow blindness caused by reflection of light from the snow, and to scurvy, the result of poor and incomplete dietary.

In mountain climates the main features are the lowered barometric pressure and the rarefied atmosphere. Mountainous districts near to the sea are often characterised by clouds, fogs, and rain, the moist currents of air from the sea striking against the mountains are chilled and can no longer retain the aqueous vapour. In the Alps and the highlands of South Africa the air, as a rule, contains but little moisture, the air reaching them from over the sea has already deposited its moisture.

The temperature falls 1° F. for every 300 feet of altitude, but if the air is dry the effect of the absence of atmospheric impurities in mountain air is to allow radiation to have full play, and objects are rapidly warmed in the sunshine to lose their heat rapidly at night so that the daily range of temperature is greater than that found at lower levels. Strong winds are very prevalent. The rarefication of the atmosphere causes a greater frequency and depth of respiration, after some time the lungs expand and the vital capacity of the chest becomes greater. The cold causes a direct increase in metabolism and is often combated by increased muscular exercise with all its beneficial effects.

These effects together with the purity of the air, the shelter found in the valleys and the sparseness of the population, cause the climate to be healthy, and mountain resorts sheltered from cold winds and with abundant sunshine are much recommended for the treatment of phthisis.

Mountain Sickness. On climbing, at a height of about 7,000 feet the body mechanism begins to fail to accommodate itself to the altered circumstances; vomiting is common and air hunger begins to be felt, noises in the head, dizziness, impairment of the senses and of cerebral action and a desire for sleep occur. Higher still, streaming at the eyes and congestion of the mucous membranes generally of the eyes, nose, ears and at times lungs occurs and may go on to hæmorrhage; any exertion causes exhausting fatigue.

The condition is due to lack of oxygen; the symptoms can be relieved by adding oxygen to the air inspired. Residence is however possible at far greater heights than these; the body becomes adapted to breathing these rarefied atmospheres. The highest dwelling place continuously occupied is the Observatory El Mirti in the Andes, 5,880 metres high.

Several natural features influence climate. In the vicinity of large sheets of water, or even rivers, the air becomes saturated with water; when chilled by being driven by the wind up inclined land or over cooler air currents it deposits its moisture which condenses as mist, fog or rain.

"Lakes and rivers are frequently in valleys where the air on the hills, cooled by the free radiation at higher levels, pours downwards in the evening and precipitating the vapour absorbed during the day, renders the valley damp and often misty."[1]

Similarly hills may cause chilly nights in waterless valleys through the descent of cooled air although the element of damp is missing.

In forests the passage of the sun's rays to the soil is obstructed by the shelter afforded by the trees; obstruction is also caused by the humidity produced by the free evaporation from the foliage, the atmosphere is thus cooled by day. Having a lower temperature than the neighbouring surface of the earth, forests situated so high as to be among water-charged clouds increase the rainfall.

Winds increase evaporation of perspiration and therefore loss of body heat unless the wind is moist and warm. A hot dry wind increases evaporation markedly but has no cooling effect, warm moist winds (the south-westerly in this country) are mild and relaxing, dry cool winds (our east and north wind) are bracing.

ACCLIMATISATION

This question may be studied, as Virchow pointed out, from two points of view, those of the race and of the individual. Adaptation of races to altered climatic conditions, in the gradual process of migration, has been over and over again exemplified in past ages, and in comparatively modern times the Gipsies and the Jews have spread over wide areas of the world's surface. In cases of colonisation in which there has been abrupt exposure to altered circumstances, the colonists have as a rule only shown ability to multiply when the conditions did not greatly differ from those of the original climate. Thus comparison may be made between the colonisation of North America by the Anglo-Saxon race on the one hand, and on the other the inability usually manifested by that race to increase and multiply within the tropics.

A. Balfour remarks that the effects of climate are inextricably mixed with those of other factors: economic, social, religious, historic, dietetic, and most important of all, medical. "In the tropics it is often almost impossible to eliminate the disease factor, especially malaria and to a lesser degree ankylostomiasis."

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[1] "Medical Climatology of England and Wales." E. Hawkins.

Admixture with native blood assists very materially the development of resistance to climatic conditions, but may produce a lowering of the physical and mental standard. Guiteras notes the tendency there has been to ignore the accomplishments of the Spaniards and Portuguese in the colonisation of the tropical parts of America. He advances evidence to show that in Cuba the white race has not only persisted but has prospered without any intermarriage with black or coloured folk and without the frequent introduction of fresh elements from the temperate zone. Guiteras thinks the Spaniard has taken kindly to acclimatisation owing to his method of living and his sobriety as compared with northern Europeans. Spain, however, is a land of the sun; many Spaniards have a touch of Moorish blood coming originally from subtropical lands. The white people of Mauritius, an island just within the tropics, hold their own with most races; a considerable proportion however possess some tincture of Indian or Creole blood.

The powers of stimulation of a climate depend more largely upon moderate changes of temperature from one day to the next than upon the relative humidity. Balfour observes that we do not yet know if marked changes in the twenty-four hours as, say, between the day and night temperature, or even considerable diurnal variations, can make up for the difference of season as experienced in temperate lands. An equability of temperature, a powerful sun and a high degree of atmospheric humidity are the climatic factors which in the moist tropics at least militate against the comfort and well-being of the white settler. In the dry tropics, excessive dryness of the air, together with sun and heat are operative. Although isolated examples such as certain islands of the West Indies, Kisar (East Indies), Mauritius and Cuba may be quoted, on the other side is the experience of centuries that the hot and humid tropics are not suited to white colonisation. As to the suitability of the dry tropics and elevated lands within the tropic zone, for colonisation by white men, so definite an opinion cannot at present be formed; very hot, dry countries are trying to the nervous system, more especially if they are plagued with high winds; women and children in particular suffer.

Altitude may have a beneficial effect in modifying the climatic effects of a country in the tropic zone, but evidence is forthcoming of a deleterious action on the nervous system. Mackinnon finds that Kenya children do well until the age of ten years is reached when a gradual process of mental exhaustion and deterioration supervenes which appears especially to affect the memory and the power of application. Other observers have noted the presence of neurasthenia among adults living at high altitudes. But the subject has not been studied sufficiently to justify a decided verdict. Sandstroem's experiments on the growth and fertility of mice subjected to an artificially produced tropical climate showed that in the fourth generation the mice showed possible signs of adaptation.

The acclimatisation of the individual may be merely a process of adaptation of the body and its organs to altered physical conditions. After arrival in the tropics a slight rise of body temperature, not more than 1·5° F. occurs, but adjustment soon takes place in most cases, though there are certain individuals obviously unfitted for tropical life, who do not possess the power of adaptation. As L. Hill has pointed out,[1] atmospheric conditions in the tropics undoubtedly impose a strain on the heat regulating mechanism of the body. Hence the very effort to keep the temperature normal tends towards exhaustion, and unfavourable conditions of diet and clothing, at least when combined with considerable or severe exercise, raise the body heat. Tanning and thickening of the skin are valuable defensive reactions. The brown-skinned man possesses a more sensitive cutaneous heat-regulating apparatus than his white brother. This is presumably due in the first instance to colour, as the light rays passing through the cutis are converted into heat when they strike the pigmented layer in the brown man, whereas in the white man the light rays pass through and are only converted into heat when they meet the blood pigment, and hence more rapidly as the result of nerve stimulation the stage is reached when perspiration shows itself. Moreover, brown skin cools more rapidly than white skin. "Persons who do not perspire or who have a defective sudorific system are unsuited to residence in the tropics and in the case of prospective settlers inquiry should always be made on this point."

Acquirement of knowledge as to and the carrying out of the regimen which is suited to the particular climate, is clearly of fundamental importance.

Obviously the subjects of gout, kidney disease, etc., are less likely to bear the strain of altered physical conditions than healthy persons. Again, the less the amount of change experienced the better, and hence the inhabitants of southern Europe more readily withstand subtropical or tropical climates than the inhabitants of northern Europe.

Acclimatisation may mean sometimes more than is indicated in the above paragraph. Negroes in temperate climates are said to be specially prone to develop phthisis. The subject, however, is by no means fully worked out as yet, and from the number of disturbing influences which have to be reckoned with, is one of peculiar difficulty. Thus there can be no doubt that the high mortality of Europeans in parts of the tropics is by no means attributable to climate alone—questions of impurity of water, deficient drainage, over-indulgence in food and alcohol, altered habits of life, altered social status, sedentary routine, all have to be considered. As this has been increasingly recognised, there has been manifested a striking reduction in the mortality of white men in the tropics, and the experience gained has materially modified earlier notions on the subject of acclimatisation.

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[1] "The Science of Ventilation and Open Air," part 2, p. 98. Medical Research Council Special Report Series, 1920, No. 52.

A. Balfour observes there can be no doubt that with due care and provided the hygienist comes to the rescue in the way of providing a healthy environment the individual white settler, man, woman or child can at the present time exist perfectly well under tropical conditions and enjoy a fair measure of health for considerable periods at a stretch. It would seem moreover that a certain proportion of white men and a few white women can carry on active outdoor life in tropical heat, year in and year out, without much detriment to their physical and mental vigour. On the other hand, others reviewing the evidence consider that the depressing effects of hot climates on the nervous system causing exhaustion and psychical irritability, for which the only cure is a prolonged holiday in a temperate climate, are inevitable to such a degree that white men cannot be said to have yet become fully acclimatised.

COMPOSITION OF THE ATMOSPHERE

The atmosphere consists in the main of a mixture of oxygen and nitrogen together with small amounts of other gases. Pure air free from aqueous vapour has the following composition by volume :—

Oxygen	20·94
Nitrogen	78·08
Argon	0·94
Carbon dioxide	0·04
Helium, Krypton, Neon, Xenon and Hydrogen	Traces
	100·00

The composition is practically constant over all parts of the earth's surface out of doors where diffusion has full play. Water vapour is also a natural constituent, but the amount present varies within wide limits.

Although the presence of oxygen in the air breathed is necessary for life, the amount present is not (within limits) of paramount importance, as the living organism regulates its own consumption.

The difference between inspired and expired air as regards the percentage of the chief constituents is as follows :—

	Nitrogen	Oxygen	Carbondioxide
Inspired air . . .	79·02	20·94	0·04
Expired air . . .	79·4	16·50	4·1
		−4·44	+4·06

but the amount of oxygen expired varies between such limits as 15·5 and 18·3 per cent. in accordance with the depth and frequency of the respirations. Under normal conditions oxygen reaches the blood by diffusion through the epithelial lining of the pulmonary alveoli, but the physical laws of diffusion do not explain the phenomenon of blood-oxygenation when a man is making a special demand on the supply of oxygen during heavy physical work. J. S. Haldane considers the evidence shows that the living cells of the epithelium possess the faculty of secreting oxygen from the air and of handing it forward at enhanced pressure to the blood. Physical training develops and improves this secretory function of the alveolar cells.

The gases constituting the atmosphere are not chemically combined, but form a mechanical mixture. This can be proved in several ways. Firstly the relative quantities of the gases are not those of the combining weights or of simple multiples of these weights, and although the composition is remarkably constant still samples of air obtained under different conditions do show slight variations. Secondly, if appropriate volumes of oxygen and nitrogen are mixed in the same proportion as found in the air no heat is evolved, as would be the case were the mixture a chemical one, and finally if a sample of air is shaken up with water and the amount of each constituent dissolved be ascertained it will be found that the water contains less than two volumes of nitrogen for each volume of oxygen, whereas in the original air there were four volumes of nitrogen to each volume of oxygen. Oxygen is more soluble in water than nitrogen, and the fact that, by merely shaking air and water together, the gases are abstracted in proportions differing from those in which they exist in air, indicates that they cannot be chemically combined in the atmosphere.

The oxygen of the air is its active constituent, it possesses the property of entering into combination with most of the other chemical elements under certain conditions, and upon these interactions the support of life on the globe, and the various processes of oxidation and combustion depend. The nitrogen, on the other hand, is a very inert gas, and its most obvious function in atmospheric air appears to be to dilute the oxygen ; it probably, however, also plays an important part in connection with the life, more particularly, of certain plants. Argon, also present in air, was differentiated from nitrogen by the fact that it freezes on exposure to a somewhat less extreme degree of cold; it is even more inert than nitrogen, and, indeed, it has not hitherto been found capable of entering into chemical combination with any other element.

In addition to the constituents of air already named, which exist in appreciable quantity, there are others, which are so constantly found (though their amount is excessively small) as to justify their presence being practically regarded as a normal condition: such are, ammonia and other nitrogenous products of decomposition, marsh gas, common salt and other mineral substances, and organic matter, dead or living. Fresh country and seaside air, moreover, is usually found to present evidence of containing what was formerly held to be ozone, but is now generally considered to be nitrogen peroxide formed by ultra-violet rays of sunlight causing the direct union of nitrogen and oxygen. In thickly populated areas organic matter is usually present in greater quantity than in fresh air; the air of towns sometimes shows, as compared with fresh air, a very slight increase in the amount of carbon dioxide, with a corresponding diminution in the amount of oxygen; furthermore, the presence of sulphur compounds can usually be detected in town air.

So slight, however, are the variations in the quantity of the constituents of air, that much difficulty is experienced in gauging the purity of any particular sample by ordinary chemical tests. The nature of the difficulty will be appreciated on consideration of the insignificance, from the point of view of weight, of impurity which none the less profoundly affects the sense of smell, or, from the same point of view, of the living micro-organism, which, when inhaled into the lungs, may produce effects of the gravest consequence.

Many methods have been devised for estimating the exact proportion of oxygen and carbon dioxide in the atmosphere, but for practical purposes it has been found sufficient to determine the amount of the latter. A considerable increase in carbon dioxide can be tolerated without injury to health, but the importance attaching to its increase up to certain limits arises from the fact that it is an index of conditions which apart from the mere increase of the gas are injurious to health. Those conditions may consist of organic emanations from the lungs and skin of persons vitiating the air of the room, also of micro-organisms which may cause definite disease, as well as alterations in the physical conditions, humidity and heat. It is therefore important to have some ready and accurate method of estimating the carbon dioxide. This was devised by Haldane,[1] who uses a gas analysis apparatus and determines the loss of volume, in the sample, before and after absorption of the CO_2 by potash solution. A gas burette with a wide ungraduated portion, and a narrow portion graduated in divisions, each corresponding to $\frac{1}{10000}$th part of the capacity of the burette, is employed. The burette is enclosed in a water-jacket, and to correct for variations of temperature, a control tube of approximately the same size and shape as the gas burette is used. The pressures under which the readings are made are determined to be the same, before and after absorption, by measuring the level of the potash solution in the narrow-bore tubing of the absorption pipette. The difference between the two readings gives the result in volumes per 10,000; no calculations are necessary, and with proper precautions the finding is reliable to within ·5 volume per 10,000.

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[1] "The Journal of Hygiene," Vol. I, No. 1, January, 1901.

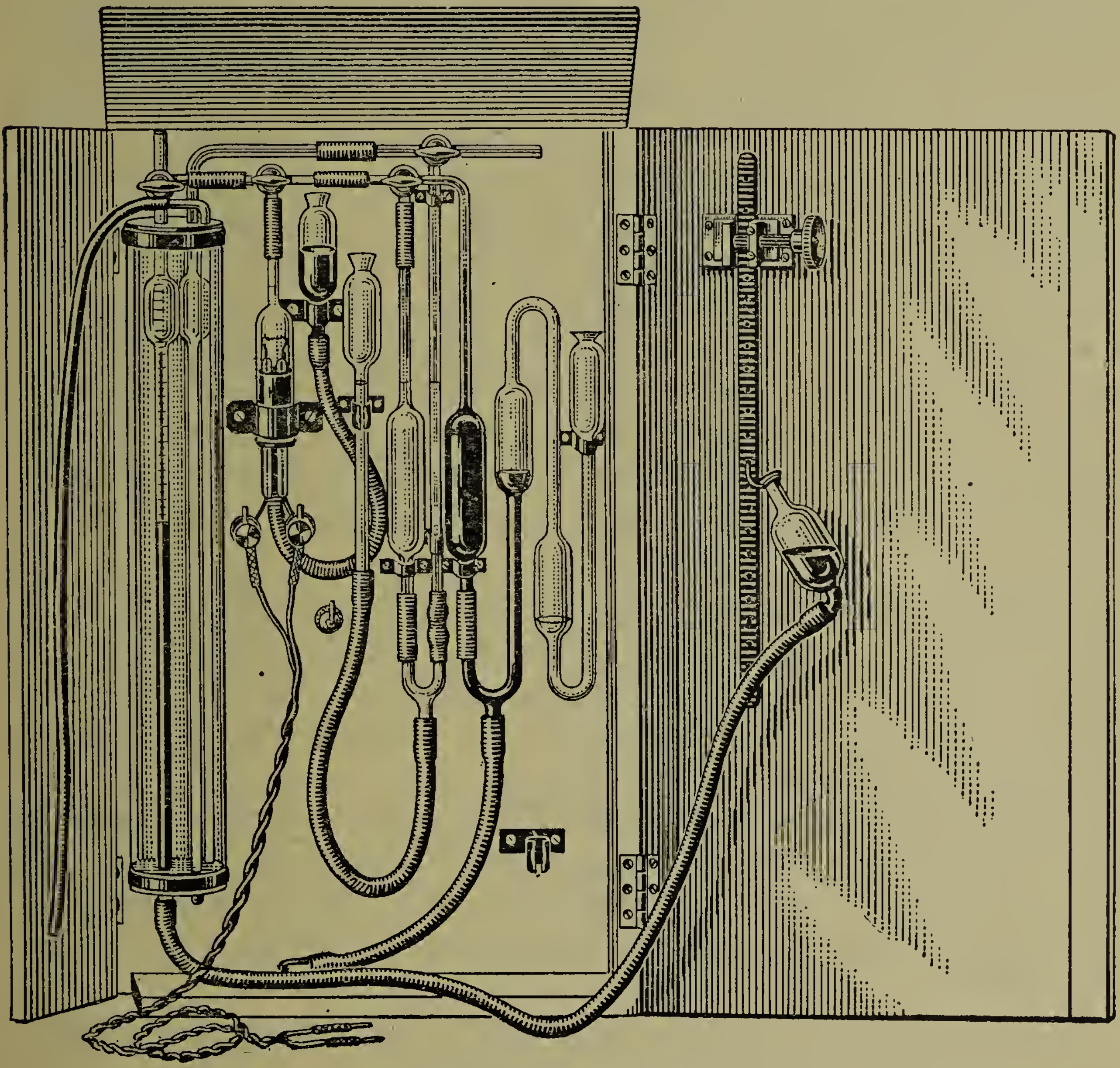

FIG. 11.—Haldane's Air Analysis Apparatus.

Other methods have been devised both by Pettenkofer and Angus Smith—but the former requires the examination of a very large volume of air and unless carried out by those who have practised the method extensively yields very uncertain results, while the latter is too rough a test for scientific purposes.

Determination of Organic Matter—This may be effected by causing water, completely freed from ammonia by doubly distilling it, to take up the organic matter contained in a considerable volume of the sample of air to be tested. The water is then analysed in order to ascertain how much organic matter it contains. The volume of air used must, of course, be carefully measured, and this is generally done by slowly drawing it through the water until it fills an aspirator of known capacity. The free and albuminoid ammonia taken up by the water may then be determined by Wanklyn's process. The oxidisable organic matter contributed to the water by the air can be estimated by Forchammer's process.

Roughly speaking, ordinary air is found to yield about ·06 of a milligramme of free ammonia, and ·08 of a milligramme of albuminoid ammonia, per cubic metre of air used. In a jar containing very impure air, ammonia may be found in such considerable amount, as to admit of its detection by inserting a strip of filter paper, moistened with Nessler's reagent, between the stopper and neck of the bottle; the paper should be allowed to hang, without, of course, touching the side of the bottle, for a sufficiently long period to enable the ammonia present to produce the characteristic discoloration.

Carbon Monoxide—The detection of this impurity in air is a very important matter, inasmuch as the gas, if breathed into the lungs, combines with the hæmoglobin of the blood, and, preventing its continuing to perform its function as an oxygen-carrier, produces asphyxiation from lack of oxygen.

Haldane found that the presence of 0·05 per cent of carbon-monoxide in air produces distinctly toxic symptoms in man and 0·2 per cent. urgent symptoms. One per cent. is a fatal admixture, but if the period of inhalation is prolonged lesser concentrations will produce a fatal result.

Carbon-monoxide is itself inodorous, but one of the most common means by which it is introduced into the air is by an escape of ordinary coal gas, which contains some 8 per cent. of it, and under such circumstances, the smell of other constituents of the coal gas usually excites attention. Carbon monoxide is contained, however, in much larger quantity in carburetted water gas which has a penetrating smell. The proportion of carbon monoxide in the mixture of straight coal gas and water gas as ordinarily supplied is about 15 per cent. Any increase in the amount of water gas added to coal gas is almost necessarily accompanied by somewhat greater risk to the consumer; on the other hand, the lessened proportion of sulphur compounds present in the admixture decreases the pollution of the air when the illuminant is burnt. Much of the risk can be prevented by more careful attention to gas mains and fittings and by prompt notification of escapes. The Departmental Committee of 1898 recommended a limit of 12 per cent. carbon monoxide and the Gas Regulation Act 1920 gives the Board of Trade power to prescribe a limit.

Carbon monoxide is also introduced when the products of combustion from furnaces and flues have access to the air of rooms. It is also liable to emanate from cast-iron stoves in which coke is used, especially when they become red-hot. The heated iron probably allows the gas to pass through it from the fire, it may also effect the reduction of the dioxide to the monoxide, or it is possible that the carbon in the cast iron itself becomes oxidised. Unfortunately there is no simple efficient method of estimating its presence. When present as a constituent of coal gas, its presence is detected by the smell of the other constituents since the monoxide itself is inodorous. The most delicate qualitative test is that of Vogel based on its affinity for hæmoglobin ; a solution of this substance when diluted and shaken up with the suspected air and to which ammonium sulphide is added shows characteristic absorption bands in the spectrum.

Sulphur Compounds are present in the atmosphere in traces in places where much coal, particularly coal containing appreciable quantity of sulphides, is used. The presence of sulphurous acid in considerable amount is readily detected by its characteristic smell and action upon litmus paper. Sulphuretted hydrogen and sulphide of ammonium also possess distinctive odours, and they may be detected by their power of darkening lead acetate paper. Ammonium sulphide may be distinguished from sulphuretted hydrogen by its alkaline reaction, and by its giving a violet colour with sodium nitro-prusside. These gases are produced in processes of decomposition as well as in those of combustion.

Other gases which may be met with as impurities in a sample of air, are chlorine, which has a characteristic smell, and which first reddens and ultimately bleaches litmus paper ; hydrochloric acid, which markedly reddens blue litmus paper, and gives a white precipitate (soluble in ammonia) on being shaken up with silver nitrate ; and nitric and nitrous acids, which also redden litmus paper (the presence of the two last-named gases may be tested for by shaking the air up with a little water and applying the tests for nitrates and nitrites, to be presently described). Carbon bisulphide may occur as a product of combustion, and is produced in connection with the manufacture of vulcanised indiarubber. In particular processes in the manufacture of bone manure arsenic is given off. Some of the effluvia evolved in carrying on certain offensive businesses, produce eminently characteristic impressions on the olfactory sense ; such are, for example, the effluvia resulting from gut scraping, blood boiling, and tallow melting.

Dust and Micro-organisms—The presence in air of dust of animal or vegetable origin is mainly of interest as serving to indicate the kind of surroundings from which the air was taken, and as suggesting what is likely to be the character of the much more minute, but far more important, living organisms contained in it. The most valuable methods of examination of the suspended matter in air, therefore, are those which relate to the cultivation of its contained micro-organisms, in or upon appropriate nutrient media, with a view to their isolation and the determination of their specific characters.

Various devices have been employed with a view to collecting suspended particles. Thus, in Pouchet's aeroscope, air is drawn by aspiration through a tube terminating in a fine point, which is directed upon a glass plate smeared over with glycerine. The particles contained in a given volume of air can thus be sprayed upon and intercepted by the glycerine, and subsequently submitted to examination. Or a known volume of air may be slowly drawn through a filter of pure sugar, and when the filter has intercepted the suspended matter, the sugar can be dissolved in a little pure water, and the material thus collected in the water may be examined as before.

In order to study further the micro-organisms contained in air, it is necessary to cultivate them in or upon the surface of sterilised nutrient media. In Hesse's apparatus air, in measured quantity, is drawn through a cylinder coated with such sterile nutrient material: the organisms are deposited upon the surface of the medium, and pure cultivations can be obtained from the colonies which develop.

As the use of the cylinder is attended with several disadvantages, it is more usual to employ a sterile filter to collect the germs, or to cause the air to pass through sterilised broth, and to afterwards examine the material intercepted by making plate cultivations with it, in such degrees of dilution as will ensure its being practicable to separate the individual colonies which appear.

A simpler method consists in exposing, to the air to be examined, for varying intervals of time, nutrient material in ordinary Petri dishes. The number of colonies which develop, after a definite number of seconds' or minutes' exposure, can then be counted, and a means of comparison between the number of organisms present in different localities, and capable of growing upon the material used, can thus be instituted. Moreover, particular colonies can, if this be considered desirable, be isolated and grown in sub-culture and submitted to further examination. It is, of course, important to bear in mind that only those species of organisms develop which are able to grow under the conditions of the experiment. Thus the colonies which appear on the surface and in the depth of nutrient gelatine, kept at ordinary temperatures, do not represent all the forms of living organisms present in the air. It is desirable, therefore, in particular cases, to work also with agar plates, which can be incubated at higher temperatures and, if it is thought necessary, the number and character of the anærobic forms present may be also ascertained. In recent investigations Frankland's method has been used; a known volume of air, usually five litres, is aspirated through a plug of glass wool in a sampling tube; the glass wool retains all the micro-organisms which are subsequently distributed through a suitable culture medium contained in a Petri dish. The aspirator used by J. G. Forbes in some recent experiments consists of two connected brass cylinders each of one litre capacity, one of which is filled with water; these rotate on a hollow axis connected with the sampling tube. Aspiration is effected by rotating the cylinders when a flow of water takes place from the upper to the lower one; the sampling tube is in communication with the upper cylinder and as the water passes out air is drawn in. The plates are cultured at body temperature (37° C.); the colonies grown consist chiefly of organisms derived from a human or animal source. A large number of organisms present in the air do not grow at this temperature; cultures are also grown at room temperature (20° C.) when the moulds develop.[1]

Bacteria are practically non-existent in the air at the summit of high mountains and in that at sea, provided the nearest land be a hundred miles or more away. Miquel found, as the average of six years' observations, about 450 organisms per cubic metre in the air of the park at Montsouris, near Paris, while in the Rue de Rivoli the corresponding average was nearly 4,000. In a hospital ward he found nearly 80,000 per cubic metre. The number observed at Montsouris attained a maximum in July, and was at its minimum in February. There was, it may be noted, marked diminution after rain; the effect is largely mechanical, the rain bringing down particles of dust to which the micro-organisms cling, very few being present other than those trapped by dust. Moisture in the air has an important influence on the growth of organisms; while dryness of the air, on the one hand, is detrimental to their survival, on the other hand, with increasing atmospheric humidity (such as occurs in overcrowding), conditions become favourable to the maintenance and development of bacteria and probably more particularly of those whose optimum temperature is that of the human body.

The work of Carnelley, Haldane and Anderson in Dundee dwelling-houses and schools [1] and of Carnelley and Foggie [2] dealt with the influence of locality, age of the buildings, cleanliness and ventilation.

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[1] "Micro-organisms in the air of the House of Commons," "J. of Hygiene," 1903, III, 498–513. M. H. Gordon's bacteriological report in Section IV of the investigation of the ventilation of the debating chamber of the House of Commons (Cd. 3068) should also be read in connection with the subject generally.

In twenty-eight naturally ventilated schools described as very dirty, a mean of 152·1 organisms per litre was obtained; but in eighteen schools in which mechanical ventilation was in use, the average number of organisms amounted only to 16·18 per litre. Where, however, better conditions of cleanliness existed, such as in private schools, though naturally ventilated, the degree of microbic pollution was found to be very considerably lower, *viz.*, nine organisms per litre. In good class and mechanically ventilated institutions where cubic space was much greater a still lower figure prevailed, *e.g.*, 2·8 and 3·6 per litre in the Dundee University College and High School respectively.

It is possible that in rooms ventilated by electrically driven fans and on electric railways the number of organisms in the air may be lessened by the influence of the electrical discharge by direct local action, radiation, or electrophoresis, in other words the deposition of germ-laden particles in such air may be favoured by electrostatic force, such as is associated with the high potential conductor rails along the course of the Tube Railways, leading to a sedimentation and trapping of matter in suspension.

The influence of cubic space, general cleanliness and number of occupants in the bacterial air was also shown by the results of observations made in various dwelling-houses.

The air of one-roomed houses yielded an average of 60 organisms per litre (12 moulds and 580 bacteria per 10 litres), of two-roomed houses 46 (22 moulds and 430 bacteria per 10 litres), and of four or more roomed houses 9 only per litre (4 moulds and 85 bacteria per 10 litres). The results of their observations of outside air varied between 0·8 per litre (2 moulds and 6 bacteria per 10 litres) for quiet places and 17·5 per litre in busy streets. A standard of air purity was suggested for dwelling-houses and schools and it was considered that a limit of 20 organisms per litre should not be exceeded, a limit doubtless rather high for present-day conditions.

Obviously the species of bacteria of most significance in air are primarily those pathogenic to man and especially those capable of producing disease when inhaled. Such organisms, however, even when present in air are difficult to detect. Although of the greatest significance when found, the detection of specific pathogenic micro-organisms in air is so uncertain in the present stage of bacteriological knowledge that failure to find them by the methods at present available, even after careful search, does not necessarily imply their absence.

The atmosphere undoubtedly at times contains living particles which are capable of producing specific disease. The spores of fungi causing skin diseases may spread from person to person in this way. The pollen of some kinds of grass is held accountable for the production of hay fever. Bacteria capable of causing disease are present in the air at times, apart from their association with droplets of saliva, expelled during coughing, sneezing, laughing and loud talking, or dust raised from the surface of the earth. Chicken-pox and probably measles are air-borne in this strict sense. L. Hill stresses the importance of infection through the nasal mucous membrane. It is certainly undesirable that workers should sit in rows facing one another on opposite sides of narrow workbenches; at least four feet of sitting space should be allowed to each worker.

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[1] "Carbonic acid, organic matter and micro-organisms in air, more especially in dwellings and schools," "Philos. Trans." clxxviii. B. 61–111.

[2] "The air of schools," "Journ. Pathol. and Bact." II, 157–173.

The great majority of organisms in air are harmless to persons in perfect health, the ciliated epithelium of the respiratory passages sweep them out as fast as they become entangled in the mucus with which the epithelium is bathed. Even those which have penetrated as far as the trachea and bronchial tubes are in the end similarly engulfed. But if only a slight catarrh of the respiratory passages exists the bacteria in air are a source of considerable danger. Such catarrhal states, especially under the influence of overcrowding during epidemics, increase the liability to attack by influenza and the acute bronchitis and broncho-pneumonia which are so largely responsible for the high mortality rates in measles and whooping cough.

ATMOSPHERIC IMPURITIES

The impurities met with in the atmosphere are suspended matter, dust and micro-organisms; gases and effluvia generated in connection with various trade processes; emanations from putrefying organic matter and various substances added to the air by the processes of combustion and respiration.

Suspended Matter—The sunbeam reveals the extent to which visible suspended particles exist in air; of the methods used to count these particles the filtration and condensation methods are the most valuable.

In the filtration methods air is filtered through various substances; sugar has been used for the examination of the air in siliceous mines, the air being aspirated through a glass tube containing fine sugar which is afterwards dissolved. Counts of the solution are made by a hæmocytometer or a Sedgewick-Rafter cell. A much quicker method is the use of the Palmer water spray apparatus recommended by the American Committee on standard methods for the examination of air. The air is sucked by an electrically driven fan through a glass bulb containing a water spray; the amount of deposit in the bulb is then determined by weighing and counting. Weighing gives information only as to the quantity of dust; to obtain evidence as to the number, size, shape and character of the particles the counter must be used. The average diameter of the particles may be obtained by working out the formula :—

$$(\text{Diameter of the particles in microns})^3 = \frac{2{,}600{,}000,}{\text{number of particles in a milligram of dust.}}$$[1]

Aitken's method depends upon the condensation of water vapour in an atmosphere subjected to sudden rarefaction. The air to be examined is diluted to a suitable extent with dust-free air and then, by addition of water vapour, each particle of dust in a measured quantity of the mixture is caused to have attached to it a minute droplet of water ; these droplets are then allowed to fall upon a surface of known area, and the number so deposited is counted. Aitken found that the number of particles per cubic inch of fresh air varies from about 2,000 in the open country, to upwards of 3,000,000 in towns, while in inhabited rooms the number may be 30,000,000.

Dust is practically universally present in the atmosphere, and apart from its influence in the formation of fog and rain plays an important rôle in hygiene ; together with the other atmospheric impurities it helps to account for the greater prevalence of pulmonary disease in towns as compared with the country. No dust, even the finest, will remain long suspended in a perfectly still atmosphere, but as a complete absence of movement rarely if ever occurs in nature we may expect the amount of dust at any given time to depend on the movements of the air, especially those in an upward direction, and the fineness of the dust. Some particles of volcanic dust may remain in the air for two or three years as was shown by the eruption of Krakatoa in 1881, but dust as fine as this is almost if not quite harmless. The common sources of dust in towns are road detritus and the weathering and drying of the superficial layers of the earth ; the nature of the dust will vary in composition as these vary.

The pigmentation of the town dweller's lungs is mainly attributable to particles of carbon ; soot and coal dust have remarkable powers of diffusion throughout the parenchyma, far exceeding that of the dust of metals and stone.

Dust and Occupational Diseases—The finer kinds of dust, under 12 microns in diameter, especially those connected with various trade processes, are the origin of much respiratory disease.[2] The physical characters of the dust exercise an important influence in this connection, and, according to the various degrees of irritation produced, cough, the expectoration of material betraying the presence of the particular dust inhaled, and dyspnœa, are likely to be sooner or later developed.

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[1] See " The Science of Ventilation and Open Air Treatment," Part II, p. 150.

[2] It has been shown by Lehmann that only about one-quarter of the dust inhaled by mouth and nostrils reaches the lung, three-quarters being swallowed.

To some extent the nature of the reaction of the lungs to the different kinds of dust can be predicted. Particles insoluble in the body-fluids are especially harmful; when carried into the air-passages they either remain as foreign bodies stimulating the ciliated epithelium to overaction in the attempt to bring about their expulsion or, if they pass into the lymph channels, give rise to a proliferation of connective tissue. For this reason dusts of animal substances such as ivory, horn and bone, and of calcium sulphate, of limestone, and oxide of iron are not associated with pneumoconiosis to anything like the same extent as the insoluble dusts of vegetable husks, emery, glass, sandstone and flint. Generally speaking, dusts are more injurious according as their chemical composition differs from that of the human body, or from the elements of which the human body is normally composed; for instance, animal dusts are less harmful than others, while dust derived from the husk of vegetable fibres is liable to produce a typical form of asthma associated with bronchitis. Many other vegetable dusts frequently associated with pulmonary disease, although comparatively innocuous in themselves, cause harm by reason of their being unavoidably mixed with the most injurious form of dust —mineral dust. The crystalline form as distinct from colloidal form adds to the harmfulness of a dust particle; such crystalline dust is frequently the cause of bronchitis, the chief of the pneumoconioses. Pneumonia is generally due to the extension of preceding bronchitis and usually assumes the form of broncho-pneumonia or fibrotic lung. Pulmonary tuberculosis does not as a rule occur as a primary disease in the pneumoconioses, but is ingrafted on previous bronchitis or pneumonia. It occurs almost exclusively in middle-aged workers and is held by Collis to be caused only by dust composed of uncombined silica such as flint, sandstone, quartz, quartzite, granite and buhrstone.

The trades in which these dust diseases or pneumoconioses are most common are the various occupations in which metallic and mineral dusts are inhaled. Among miners great differences are observed; in the colliers of the north of England, who work in well-ventilated mines, and who are mainly exposed to particles of carbon, the mortality from pulmonary disease is not particularly high; indeed, these men seem to suffer to a less extent from pulmonary tuberculosis than might have been anticipated, and this has been held to be due to some property of coal dust which renders it antagonistic to tubercle. It appears, however, that there is little to be said in favour of this contention, for miners are, for the most part, picked men, and their freedom from pulmonary tuberculosis does not seem to be more pronounced than might be expected to be the case on this ground alone. At the other end of the scale from the colliers stand the Cornish or tin miners; these last-named workers inhale a mineral dust of very irritating character, and their mortality from pulmonary tuberculosis is exceptionally high.

Again, quarrymen, cutlers, and file makers usually show high mortality from lung diseases, and the frequency of occurrence of lung-mischief among earthenware manufacturers is indicated by the common application of the term "potters' asthma" to the malady which contributed largely to the high mortality observed in the potteries. The irritating elements at work, in the occupation last referred to, appeared to be the angular particles of silex derived from the potter's clay. In the process of "china scouring," in which the flint dust is brushed by women off the china ware after it has been baked, clouds of dust particles are produced, and this particular branch of the earthenware manufacture is especially associated with damage to the tissue of the lung.

In 1899 Birmingham drew attention to what he termed "ganister disease," a malady which affects workers engaged in the ganister industry in the valley of the Don, between Penistone and Sheffield. Ganister is a hard siliceous stone which is obtained by blasting with dynamite, and is then crushed. The material is subsequently ground wet, and moulded into bricks, which, being pre-eminently fire-resisting, are used for lining the bottoms of Bessemer converters and crucibles for moulding steel. Legge's inquiries showed that among ganister miners the incidence of pulmonary tuberculosis was found to be ten times as great as in the general male population at corresponding ages. Among workers in the material, at the surface, the mortality was excessive, but to nothing like the extent observed in the miners. Andrewes, who examined the lungs of two fatal cases of ganister disease, found that the primary changes were dependent upon the irritation of the inhaled dust, which had given rise to a fibrosis, lymphatic in its distribution in its earlier stages, but subsequently extending to large areas of lung tissue. Upon this fibrosis a secondary tuberculosis was later grafted.

The metallic dust produced in some of the Sheffield trades is, if anything, more injurious than the siliceous dust of the potteries, and can only be compared with the worst kinds of stone dust. In button making, and particularly in connection with the cutting and polishing of mother-of-pearl buttons carried on at Birmingham, a heavy dust is produced which is especially liable to cause fibrosis of the lungs. Again, in association with pin-pointing and with the needle-making industry at Redditch, respiratory diseases are commonly observed; moreover, in certain finishing departments in electro-plate manufactories, in which articles are rubbed with a polishing powder, dust which possesses irritating properties is evolved.

As regards vegetable dusts, those derived from cotton and flax most frequently produce disease. In the manufacture of cotton, moreover, the china clay which has of recent years been used for sizing the warp gives rise to a dust which produces disease, and its ill effects appear to be aggravated by the fact that the clay is manipulated in a moist atmosphere. Flour dust seems to be comparatively innocuous; ordinary sawdust is moderately irritating; the dust of some woods such as boxwood, teak and sequoia owing to the contained alkaloids have marked effects, both local, on mucous membranes and the skin, and general on the circulation. In the main the dusts above mentioned act as mechanical irritants; there are certain other dusts and vapours evolved in various trades processes which produce symptoms referable to their chemical composition. Prominent among these is *lead*,[1] which in its metallic form or as one of its compounds is now used in some 111 industries. The prevention of lead poisoning has been the subject of much attention with fortunate results.

In 1923, 337 cases of lead poisoning were reported, 25 of which were fatal,[2] the greatest number being constituted by the following industries, viz., electric accumulator works $(95)^{2}$, plumbing and soldering $(46)^{1}$, smelting of metals $(19)^{2}$, manufacture of china and earthenware $(44)^{11}$, manufacture of white and red lead (37), coachbuilding (134), printing $(6)^{1}$. The use of paints and colours also accounted for a considerable number, but as cases occurring among house painters and plumbers are not notifiable the exact number could not be ascertained.

In electric accumulator works the perforated plates in the accumulator are coated with a paste made of several oxides of lead mixed with dilute sulphuric acid; this is rubbed or pressed into the plates.

In lead smelting, fumes of the metal are given off, the inhalation of which is very dangerous. Formerly the fumes caused a deposit of lead on the land round the works, but this has now been minimised by passing them up chimney stacks 100 to 150 feet high. The most dangerous part of the work is the cleaning out of the smelting stacks or flues.

In the manufacture of earthenware and china, lead pigments are used for decorative purposes, but the chief danger lies in dipping the pottery into the glaze which as a rule contains lead. This can now be done by machinery; also many manufacturers now use leadless glazes.

In the manufacture of white lead, danger is most likely to occur when the Dutch method is used. In this thin sheets of lead are exposed to the vapour of acetic acid ; the subacetate formed is exposed to carbon dioxide evolved from tan, thus producing carbonate of lead. The women who used to remove the white lead and to grind and pack it, formerly suffered much from plumbism. Wet grinding and the enforcement of absolute cleanliness have reduced the danger to a minimum. White lead is used mainly for making white paint ; endeavours have been made to find an equally efficient substitute ; of those tried hitherto none possess the durability and protective power of white lead. The Home Office has issued a set of special preventive measures to be adopted in this process.

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[1] It may be mentioned here that lead, arsenic, mercury, aniline and carbon bisulphide poisoning, anthrax, toxic jaundice, epitheliomatous or chronic ulceration contracted in any factory or workshop must be notified by a medical practitioner to the Chief Inspector of Factories, Home Office, London, S.W. Forms for notification may be obtained from that address. See Form 304 of Factory Dept., Home Office.

[2] The raised figures relate to deaths.

Women and young persons, *i.e.* those under 18 years of age, are now excluded from employment in certain processes connected with lead, by the Women and Young Persons (Employment in Lead Processes) Act, 1920.

In the manufacture of red lead the packing is still a source of danger.

In 1923, consequent on the use of lead paint, 13 cases occurred in coachbuilding, 9 in shipbuilding, 10 from paint used in other industries, and 9 at least from paints and colours. Sandpapering painted surfaces to obtain a smooth polished surface is responsible for most of these cases ; damping the surface beforehand is advocated. In many of the industries where lead paint is used the illnesses are probably due to absorption of lead through the skin, unwashed hands and dirty nails, part of the poison being conveyed to the mouth and absorbed through the alimentary canal. Some of the illnesses caused by paints are probably due to the vehicle rather than the metallic pigment. Emanations from freshly painted surfaces, including " unsaturated aldehyde," turpentine, benzene or petroleum spirit, and the evolution of carbon monoxide from the drying of thin layers of linseed oil, have at various times been blamed for ill health. Inhalation of the fumes of quick drying paints which are made with the addition of benzene or spirit instead of oil, is especially harmful.

In type setting, printers often place the types they are handling in their mouths, and as type metal consists of an alloy of lead and antimony this habit and the eating of their food without washing the hands should be discouraged.

In the manipulation of plumbers' supplies the chief sources of danger are lead piping and solder, and the same precautions as to cleanliness are the best preventive.

In filecutting by hand the piece of soft iron to be made into a file is chiselled while strapped to a bed of sheet lead. The use of machinery is gradually replacing hand work.

Copper poisoning is said to occur in a few industries. Arlidge believed that under certain circumstances " copper colic " (nausea, vomiting, diarrhœa) is undoubtedly met with. " Brassfounders' ague," which occurs among persons who inhale the metallic dust produced in particular operations carried on in brass foundries, has been attributed to fumes of zinc oxide, but it is probably really in the main due to chronic copper poisoning. The symptoms of this peculiar malady simulate ague, but are not truly periodic; they include local paralysis, tremor, emaciation and cutaneous eruptions, but it may be fairly doubted whether these symptoms are due to the copper or the contained lead, arsenic and other poisons often associated with it.

Chronic brass poisoning occurs as the result of inhaling the minute particles of brass in the air of workshops where the alloy is manipulated. The principal offender is the copper.

Mercurial poisoning occurs in trades where metallic mercury or mercury salts are used, *e.g.* in chemical works, in "water gilding" (an amalgam of mercury and gold is used), in silverers of mirrors and in makers of thermometers and barometers.

Workmen employed in the manufacture of paints and colours and of arsenical wall-papers, and the makers of artificial flowers, suffer from arsenical poisoning, and this malady has also been produced from time to time in persons who have merely inhaled the dust of rooms papered with wall-paper coloured with certain compounds of arsenic.

The occurrence of "house poisoning" by *arsenic* from such sources as wall-paper, clothing, articles of furniture, stuffed birds, etc., has been confirmed by the Swedish Commission.[1]

Fumes of *phosphorus* produce necrosis of the jaw, but fortunately the red amorphous phosphorus and a sulphide of phosphorus have replaced, to a considerable extent, the yellow phosphorus which formerly caused so much harm to those who worked with it, especially in the manufacture of non-safety matches. In the manufacture of bichromate of potash, dust is evolved which causes irritation and ulceration of the lining membrane of the nose. Portland cement manufacturers suffer from lung diseases as a result of inhaling dust, and traces of cyanogen compounds are said to be given off during the "burning process." Specially injurious fumes evolved in trade processes are the vapours of silicon fluoride produced in the manufacture of superphosphate manure, benzene carbon bisulphide and various chloro derivatives used in the rubber industry, sulphurous acid evolved in bleaching works, sulphuretted hydrogen of certain chemical works, and the hydrochloric acid vapours of alkali works.

Other poisonous fumes include various derivatives of benzene and some varieties of turpentine. Nitro-benzene and especially amino-benzene (aniline) also give off poisonous fumes. Dinitro-benzene is an ingredient of roburite, an explosive much used in mines. The fumes from this produce distinctive symptoms of which drowsiness, passing in

[1] Petrén, "Acta Med. Scand," 1923, Vol. LVIII, Fasc. ii–iii. (in French).

extreme cases into coma, is especially noteworthy. The symptoms observed in melinite (tri-nitro-phenol) poisoning are due to picric acid.

Trinitrotoluene was the cause of much illness among munition workers, a prominent symptom being toxic jaundice. The most important channel of entry is the skin.

In some weaving sheds, and in connection with other trade processes, the air is steamed, and excessive humidity, together with heightened temperature, is produced. Ventilation is often imperfectly carried out, and impurities accumulate under such conditions.

Special rules are in force for each trade certified as dangerous by the Home Secretary under Section 8 of the Factory and Workshop Act, 1891.[1] These rules in addition to special precautions deal with such matters as arrangements for adequate ventilation including suction fans to draw away fumes, the provision of washing appliances, the wearing of aprons, overalls, and respirators, the provision of remedies and of places apart from the work place for eating food and examination by the certifying factory surgeon who has powers of temporary or total suspension from work. An important measure is the general education of workpeople as to the risks run and the modes of prevention.

Offensive Trades—In a number of trade processes offensive effluvia are produced, the ill effects of which are not limited to the factory; the surrounding atmosphere becomes contaminated and nuisance results, which may affect persons living at some distance from the particular trade premises concerned. Certain of these " noxious " or " offensive " trades, as they are called, are regulated by bye-laws. The Public Health Act of 1875 prohibits the establishment, without the consent of the local (urban sanitary) authority, of the businesses of a blood-boiler, bone-boiler, fellmonger, soap-boiler, tallow-melter or tripe-boiler, or " any other noxious or offensive trade," and provides for the making of bye-laws regulating these trades, if they are once established. Model bye-laws, dealing with the trades specified, and also with those of blood-drier, leather-dresser and tanner, fat-melter and fat-extractor, glue and size maker, and gut-scraper, have been framed by the Local Government Board.

In London the offensive trades as controlled by bye-laws under several Acts are :—

(1) animal charcoal manufacturer
(2) bone-boiler
(3) blood-boiler
(4) blood-drier
(5) cattle slaughterer
(6) fat-melter or fat-extractor
(7) fellmonger
(8) fish-skin dresser
(9) fur-skin dresser
(10) glue and size maker
(11) gut-scraper and catgut maker
(12) knacker
(13) manure manufacturer
(14) poultry slaughterer
(15) soap-boiler or tallow-melter
(16) tallow-melter
(17) tripe-boiler

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[1] See " Redgrave's Factory Acts " (published 1924), p. 317.

The trades of vendor of fried fish, fish curer, and rag and bone dealers are controlled by bye-laws made under L.C.C. (General Powers) Act, 1908 (Sec. 9).

Ballard, investigating the subject of effluvium nuisances, found that, speaking generally, the symptoms commonly attributable to the inhalation of noxious effluvia of the kind investigated were, loss of appetite, headache, and digestive disturbance. These symptoms are likely to be particularly marked in persons in a poor state of health, or suffering from chronic disease, and are naturally of more serious import in children, and in old and feeble persons, than in strong, healthy adults.[1] Complaints are more frequent in the summer.

Sir George Newman in his Annual Report for 1922, p. 146, says :—

" The assumption is often made that essentially offensive trades should be regulated by local authorities solely on the ground that the effluvia which may arise from them are *per se* injurious to health, *i.e.* that control should not be exercised unless the medical officer of health is in a position to prove such specific power of injury in every such trade. A control that was founded on a medical basis as strict as this could not of course logically be restricted to offensive smelling processes, but would cover all possible toxic emanations, whether considered ' offensive ' or not. For the majority of these trades which are regarded as essentially offensive under the Public Health Acts, however, the principal factor concerned is rather annoyance produced by the effluvia and its potential capacity to injure health, than any specific danger which can be proved to result from them. With modern trade developments, the number of subsidiary trades or processes has increased so greatly that the method of control by bye-laws relating to a single part of the business in which offensive effluvia may arise tends to become more difficult."

The *blood-boiler* boils blood, usually with admixture of common sulphuric acid, and then dries it, and in these processes an extremely sickening smell is usually produced.

The *blood-drier* allows blood to settle with a view to separating the serum from the clot, and then dries the former in shallow pans, in a room heated to about 120° F. Serum-albumen is thus produced, while the discarded clot is generally used for manure making. In this business the blood manipulated must be comparatively fresh, and the trade should not give rise to offence.

The *glue and size maker* boils down tannery refuse such as clippings of skin, etc., also bones, with the object of extracting the gelatine. When the supply of these soft materials runs short, dried materials such as sinews, parchment waste, dried fleshings, salted pieces, etc., are used. These materials are first soaked in lime, a procedure which facilitates the extraction of the gelatine ; the raw material is then washed in running water and any lime remaining neutralised by a mineral acid. Next the material is boiled in steam-jacketed pans, the vapours given off being passed through a furnace. The boiling is carried on inside a "closed chamber." After the fat has been removed by skimming, the remaining liquid which contains the gelatine is poured out into shallow troughs or pans to solidify when it is sliced and dried. The residue left in the boiling pans after running off the glue, is termed "scutch"; after being hydraulically pressed to extract the fat, it is used in the making of manure.

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[1] See sixth, seventh and eighth reports of Med. Off. of the L.G.B., also M. Young, " Smells or Effluvia, Public Health," 1916.

In a newer process for making glue from soft materials the cooking takes place in wooden vats, the water being heated by steam pipes; the temperature reached varies from 50° C. to 100° C. Though very little smell arises, the boiling is usually carried out in a closed chamber. The liquid glue after filtration is run into coolers; the first running is transferred to the ordinary cooling troughs, but the remainder passes to a large boiler where the liquor is further concentrated *in vacuo* before running into troughs and passing it on to a cooling chamber. The drying is completed in a tunnel-like chamber through which heated air is driven by large fans.

When glue is made from hard materials, *e.g.* bones, these are broken up and the fat (subsequently used to make soap) extracted by benzene; the broken bones are placed in digesters covered with water and treated for 24 hours at a temperature of about 112° C. by means of steam under pressure. The liquid part yields glue, the degelatinised bone being ground up and sold for use as bone manure.

The *bone-boiler* boils bones with a view to extracting the gelatine and fat adhering to the bones. After boiling they are dried, and the long bones are used for handles of forks, knives, etc., while the other bones are generally converted into manure. It is a common practice in this trade to allow large heaps of bones to accumulate in what is known as a "bone hole," and when this is done there is risk of the production of great nuisance.

A *fellmonger* prepares sheep-skins for the leather dresser. After a preliminary soaking of the skins in water in large tanks ("pokes"), the wool is detached by painting the inner side of the skins with a solution of slaked lime and sodium sulphide, which act as depilatories; the wool is easily detached in from 12 to 24 hours without causing any nuisance. Earlier processes used to remove the wool involved some degree of putrefaction of the skins and caused a serious nuisance; now any nuisance arising is due to want of general cleanliness in dealing with animal products, and the emptying of the "pokes," a procedure made as inoffensive as possible by causing them to be emptied in the early morning.

Originally the wool was detached by hanging up the skins in the open air for some weeks, decomposition took place, making it easy to detach the wool from the skins. This process was most offensive. Later, this procedure was superseded by placing the skins in a closed chamber and exposing them to the action of steam at a temperature of 90°–100° F., thus causing loosening of the wool (by putrefaction) in a couple of days.

The *tripe-boiler* converts the first stomach, or "paunch," of oxen or sheep into "tripe." As the material manipulated in this business must be fresh the smell which results should be merely that of cooking on a large scale; the contents of the stomach unless carefully disposed of cause an offensive smell. Another source of offence is want of cleanliness in the yard and building generally. The tripe-boiler often also prepares cowheels and sheep's trotters for food, and he occasionally manufactures neatsfoot oil. Sometimes waste material too putrid to be used for food is manipulated on the premises upon which the food is prepared, with a view to extracting size and fat; when this is done, there is great liability to the production of nuisance.

Soap-boiling consists in boiling together tallow and alkali. The neutral fats are composed of a combination of glycerine with fatty acids, and in the process of saponification the alkali (soda or potash, as the case may be) replaces the glycerine, forming alkaline stearates, palmitates and oleates; in other words, soap. In the case of soft soap, potash is used as the base; in that of hard soap, soda is employed. The "lye," as the alkali is called, is run into the boiling pans which contain the melted fat, and the soap formed is caused to float on the surface of the liquor in the pan, by the addition of common salt, soap being insoluble in strong saline solutions. The soap is then poured into frames in which it sets, and it is afterwards cut, by means of wires, into bars of appropriate size. This trade was associated with the production of serious nuisance years ago, when soap makers commonly rendered fat, and manufactured the alkali which they used, upon the soap-making premises. At the present time the altered custom of the trade causes the process of manufacture to be comparatively free from offence.

Gut-scraping is a particularly offensive business. The gut-scraper cleans the small intestines of pigs and sheep, and the gut, after soaking it for a while in brine, is scraped on a bench with wooden scrapers, the object being to remove the contents and internal lining, leaving only the peritoneum and a portion of the muscular wall behind. The gut thus prepared is either cut into lengths to be used for sausage-casings, or if the scraped gut is to be converted into catgut, lengths of it are sewn together, steeped in carbonate of sodium, spun by means of a spinning wheel, and then bleached by exposure to sulphurous acid, and finally dried.

The *tallow-melter* "renders" butchers' fat, in order to extract the tallow, the residue, consisting of muscular and connective tissue, is pressed in hydraulic presses, to form the "greaves" which were, at one time, sold as dogs' food, but are nowadays, as a rule, merely fit to be made into manure. The boiling process was formerly largely conducted in pans heated by direct fire heat, and unless these pans were constantly stirred, the fat was likely to burn, producing a very offensive odour; considerable improvement has resulted since steam-jacketed pans, or pans in which the fat is heated by free steam, have been substituted for fire-heated pans and the vapours caused to pass under a furnace, though an unpleasant smell is produced, even under the improved conditions, if the material is at all tainted, as it usually is, at any rate in warm weather.

The *fat-melter*, or *fat-extractor*, carries on a business similar to that just described, but deals with fat already once rendered ; fat-extracting in large towns mainly has concern with the utilisation of hotel and restaurant waste, the fat contained in which is abstracted, while the residue is commonly devoted to pig-feeding purposes.

Tanning is often a very offensive trade. Hides of large animals are tanned by soaking them in progressively stronger solutions of oak bark or nut galls reinforced by extracts containing tannin. Chrome tanning is used for the skin of smaller animals, *e.g.*, goats ; these are soaked in a bath containing a mixture of potassium chromate and sodium hyposulphite ; very little nuisance occurs if the walls and floors of the room in which the work is carried out are kept clean. In some processes with the smaller skins " puer " (dogs' dung) or pigeons' dung may be used to render the skins supple. This may be a very offensive process, but will probably be replaced by a less offensive one in the near future.

Fish-frying is a common source of objectionable smells. The fish are usually placed in a small vat of cotton-seed oil heated over a fire. If specially designed cooking ranges are used for the purpose the oil should not be decomposed by heat, another source of smell. The heating of inferior oil causes smell. The best dripping is usually recommended as the medium, but refined cotton-seed oil does equally well : the oil must not be used too often. A hood over the fireplace connected with a flue carries off the fumes.

In all these trades nuisance is likely to result, from the storage of offensive substances, unless these be kept under proper conditions (for example, in suitably-covered receptacles of non-absorbent material), and from accumulations of dirt and filth, splashings on walls, collection of pools in badly-paved floors and similar causes. Nuisance experienced at a considerable distance from the premises mainly results from failure to consume the offensive vapours produced in the process of manufacture. These vapours should either be condensed, or burnt by being passed through a furnace fire.

In Fig. 12 the method commonly adopted for the consumption of offensive effluvia evolved from fat-melting pans is indicated. A similar method is applicable in connection with many of the other boiling processes which have been referred to. The draught in the chimney draws the vapours which traverse the pipes G through the ashpit C and the fire B, and they escape to the flue along the channel marked H. The fire is thus fed by air sucked through the narrow opening beneath the hinged portion attached to the lid of the pan F, and this air carries with it all the vapour produced in the process of boiling, so that the offensive gases are subjected to the heat of the furnace before they escape through the chimney into the outer air. If the door of the fireplace D, or that of the ashpit E, be allowed to remain open, the suction of the vapours from the boiling pans is of course interfered with.

A certain amount of vapour, however, is sure to escape into the chamber in which the boiling-pans are fixed, and indeed such escape must occur in connection with stoking operations, or when the lids of the pans are thrown open for the purpose of ladling out contained materials. It is a common practice, therefore, to convert the boiling-house into a "closed chamber," and to arrange for propelling the vapours which accumulate in it by means of a fan or fans along a shaft, thus leading them to a point immediately beneath a furnace, in which they are consumed. The vapours from bone holes, etc., may be similarly treated. Provision for the access of fresh air to such closed chambers must, of course, be made; sometimes this is done by merely leaving a space at the lower part of one of the doors, but under such circumstances, what is intended to be an inlet is apt at times to become an outlet, and far better results are obtained by propelling fresh air into the closed chamber by means of a fan.

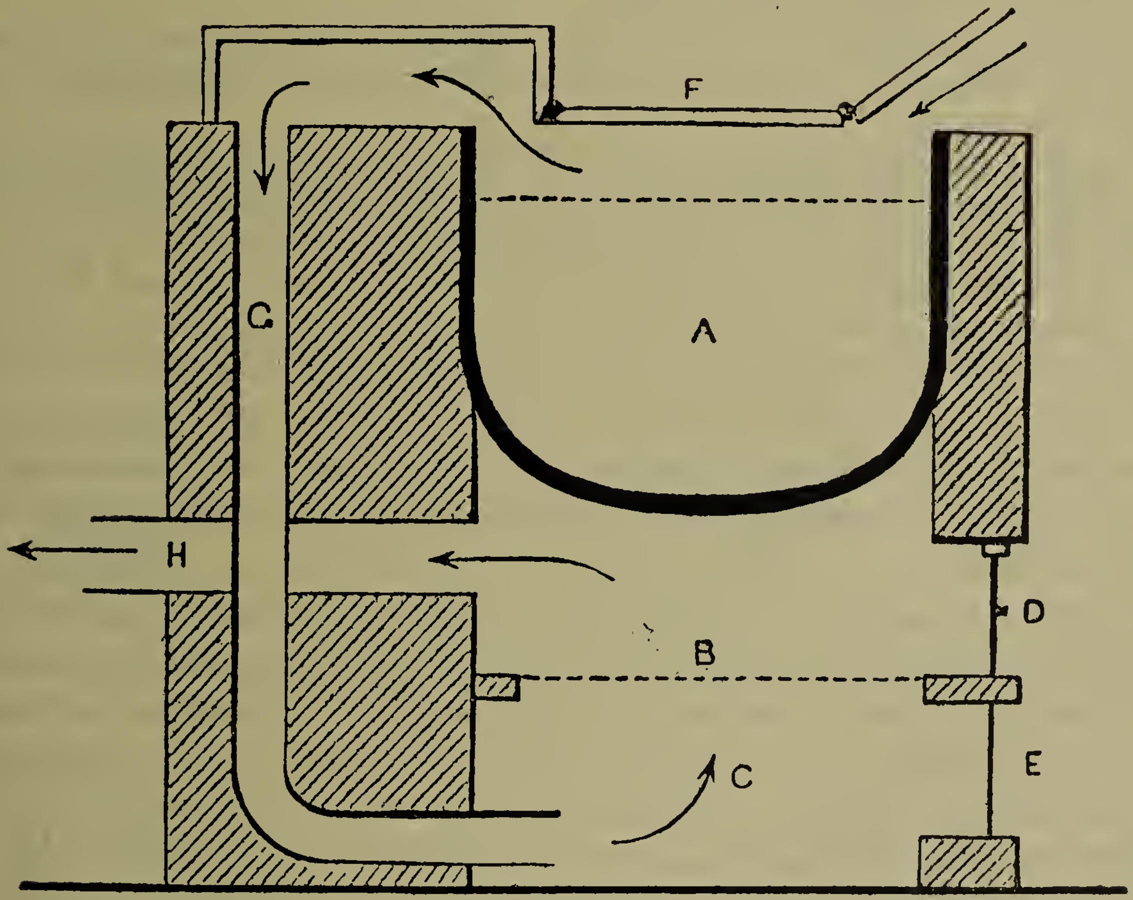

FIG. 12.—Method of Consuming Vapours from Boiling-pans. (*After Ballard.*)

The various sources of nuisance which have been referred to require to be borne in mind in connection with framing codes of bye-laws. The Public Health (London) Act, 1891, gives power, it may be noted, to regulate not only the conduct of the business, but also the structure of the premises on which the business is carried on.

The construction of the closed chamber is regulated by the L.C.C. Bye-laws which state:—

(*a*) That a "closed chamber" must be made of brick, stone or concrete, or other suitable impervious material, and no air must escape outside except by exits specially provided.

(*b*) The lighting must be by glass not less than one-eighth of an inch in thickness, and the windows must be made not to open, and shall, where necessary, be protected cxternally by a wire netting with a mesh of not more than half an inch.

(*c*) The doors must be self-closing.

(*d*) The inlets must prevent the escape of air from the chamber to the external atmosphere, and must be fitted with fan or other suitable appliance so as to keep the air fresh.

(*e*) Outlets must be provided with a fan or other suitable appliance capable of effectually conveying the air into or through a furnace fire or other apparatus so as to deprive such air of all offensive or noxious properties.

(*f*) The inner walls of the chamber must be covered with an impervious material up to six feet at least.

(*g*) The "closed chamber" must be drained by a gully *inside* the building.

Ballard in his report considered other sources of nuisance which cannot be dealt with as offensive trades, *inter alia*, the source of, and means of minimising, nuisance arising from keeping pigs, cows, horses, and poultry. With regard to the slaughtering of animals, the businesses of a knacker[1] and a butcher were especially considered; a knacker is a person whose business it is to slaughter horses and to utilise the skin, flesh, bones, etc. Thus, on a knacker's premises a number of processes, bone-boiling, boiling of flesh for the purpose of making cats' meat, fat extracting, etc., are usually carried on. In addition to the ordinary sources of nuisance associated with the keeping of animals, effluvia may be produced in connection with the slaughtering of horses and cattle, from want of care in regard to the conduct of the special processes of the business, and from the retention on the premises of putrefiable materials. On the premises of knackers large numbers of dead horses are sometimes allowed to accumulate, giving rise to serious nuisance. In this business, moreover, smell is likely to be complained of in connection with various boiling processes, unless proper means for consuming the noxious vapours, and preventing their escape into the outer air, are adopted.

In the distillation of wood disagreeable vapours escape; in the manufacture of oxalic acid by treating sawdust with an alkali and subsequently boiling with lime, and again when the oxalate formed is finally decomposed with sulphuric acid, irritating fumes are liable to be produced. In paper making, the boiling of esparto grass with alkali yields very offensive effluvia. Again the process of retting flax, which consists in steeping the flax plant in pits, is a source of disagreeable smell. Other trades liable to cause smells are the making of india-rubber, of floorcloth and linoleum, the manufacture of oil varnishes, and the distillation of certain vegetable oils.

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[1] Note that the trade of a knacker is an offensive trade in London and it may not be newly established.

Among trades in which mineral substances are principally dealt with, cement making, which has already been referred to, is a process which sometimes causes nuisance at a considerable distance from the works. Brick-burning, when it is conducted in "clamps," and particularly if dustbin refuse is used in making the bricks, is almost always a source of considerable offence. When the bricks are fired in close kilns, there is much less likelihood of nuisance being produced. In the salt-glazing of earthenware, the process of "salting" gives rise to copious white vapours (called "roger" by the workmen), which contain hydrochloric acid and cause much annoyance to those who inhale them. In the manufacture of gas for illuminating purposes, nuisance sometimes arises in connection with emptying the purifiers, and with disposing of accumulations of "blue billy," as the lime which has absorbed carbon dioxide and sulphuretted hydrogen is termed.

The remaining group of these trades includes general chemical works, rag and bone collecting, the manipulation of the refuse of towns, and the manufacture of manure.

Under the "Alkali, etc., Works Regulation Act," alkali works and allied trades, such as chemical manure, nitric acid, bleaching, and gas-liquor works, are made subject to special regulations and to inspection by inspectors appointed by the Local Government Board. The Act provides that 95 per cent. of the hydrochloric acid gas given off shall be condensed, and that not more than one-fifth of a grain of hydrochloric acid, or more of the acid gases of sulphur and nitrogen than the equivalent of four grains of sulphur trioxide per cubic foot of air, gas, or smoke, shall escape into the atmosphere.

Manure making is a comprehensive term which includes many kinds of industry. "Superphosphate manure" is made by treating ground bones with sulphuric acid. The vapours evolved contain arsenic, small quantities of antimony, and fluoride of silicon; the manure after mixing is usually placed in what is called the "hot den," in which it is allowed to remain until it cools. "Poudrette" is a manure prepared by adding sulphuric acid to night-soil. Fish manure is prepared on a large scale in the neighbourhood of large towns, from fish offal. Blood, "scutch" from glue works, hair from fur factories, and other animal refuse, shoddy waste, sawdust from chair manufactories, and many other materials, are used in the preparation of various manures.

The manufacture of manure from waste animal products is a very offensive process and as up to the present it has been found impossible to prevent the smell travelling a considerable distance from the factory, the process should only be carried out in a place remote from dwellings. The same holds of the manufacture of fishmeal made by evaporating fish offal in a cauldron *in vacuo.*

The Air of Mines

The air of mines is liable to possess certain special characters. In deep coal mines the amount of carbon dioxide may exceed two parts per 1,000 ; the air is usually, moreover, almost saturated with moisture, and it may contain excess of organic matter. In mines in which gunpowder or explosives are used, carbon-monoxide and nitrous fumes are present and in stagnant blind ends are a source of danger unless these are ventilated by compressed air hoses before the miners enter. Nitrous fumes cause a sense of irritation at the time of inhalation, smarting of the eyes, coughing, etc. These symptoms pass off quickly, but after a short interval (4–8 hours) acute œdema of the lungs may set in with a fatal result.

"Black-damp," or "choke-damp," which in the main consists of nitrogen, with about one-seventh of its volume of carbon dioxide, is liable to occur under ordinary conditions and apart from any explosion.

The oxygen of the air is used up as the result of oxidation processes occurring in coal, iron pyrites, etc. ; a similar collection of de-oxygenated air is found in wells, especially when the barometer falls and air comes out of the soil into the well. The terms "fire-damp" and "after-damp" are employed by miners ; "fire-damp" is gas which is liable to cause explosion, "after-damp" the gas which collects after an explosion, and as a result of it.

"Fire-damp" is methane ; mine fires cause explosion of the mixture of this gas with coal dust, but the gas itself is not poisonous. The dangerous substance in "after-damp" is carbon-monoxide ; asphyxiation due either to "black-damp" or "fire-damp" is the result of want of oxygen. Sulphuretted hydrogen and sulphurous acid are present at times in the air of mines but rarely in dangerous quantities.

Absorption of Gases

Reference must be made to the power of absorbing gases possessed by certain substances. Charcoal is a familiar instance of this, and a like property is manifested by spongy platinum. Many liquids, too, absorb gases. Bunsen found—supposing the gas, liquid, and temperature to remain the same—(*a*) that the weight of gas absorbed is proportionate to the pressure, in other words, the volume absorbed is practically the same at all pressures ; (*b*) that the lower the temperature the greater is the weight of gas absorbed ; and (*c*) that the quantity of gas absorbed by a liquid is independent of the nature and amount of other gases which it may hold in solution. At the ordinary temperature, and under a pressure equal to atmospheric pressure, water dissolves nearly $\frac{1}{20}$th its own volume of oxygen, but only $\frac{1}{40}$th its own volume of nitrogen; it dissolves almost exactly its own volume of carbon dioxide, and more than 400 times its own volume of ammonia.

Effluvia from Putrefying Organic Matter—Emanations of the sort now in question have already been incidentally referred to, but it remains to make particular mention of certain special cases. Decomposing sewage is one of these. In ill-ventilated and badly laid sewers cases of death from time to time occur; they are due as a rule either to inhalation of sulphuretted hydrogen, or to the presence of excess of carbon dioxide or other gases, with corresponding diminution of the amount of oxygen. In connection with cleansing old privies and cesspools, acute symptoms have been produced in persons exposed to the effluvia evolved. Such cases are fortunately, however, quite exceptional, and the main question to be considered with regard to sewage emanations is their effect upon health, when inhaled in a less concentrated form than has sufficed in the rare instances above mentioned to produce acute poisoning; further, there is the possibility of the transmission of particular forms of infectious disease by sewer gas.

The composition of the air of sewers has been investigated on numerous occasions, and it has been generally found, in the case of fairly well constructed main sewers, that carbonic acid is not greatly in excess, and that there are the merest traces of sulphuretted hydrogen and of offensive organic matter. The air of main sewers does not, therefore, as a rule, show very marked difference in chemical composition from the ordinary atmosphere; but, of course, a great deal depends upon the construction, and condition as regards ventilation, of the particular sewer in question. Again, the state of the air in a large sewer cannot be regarded as indicating the chemical composition of the air in all the drains connected with it. Inquiries as to the health of workers in sewers have led to the general conclusion that these men are not particularly unhealthy, but such investigations have never been carried out on a very comprehensive scale.

The micro-organisms of sewer air have also been made the subject of study, and it has been shown that the total number of germs present is not specially great, and that as regards their character, they appear to correspond much more closely with forms occurring in the atmosphere in the neighbourhood of the sewer, than with varieties present in the sewage itself. There seems to be no question, however, that persons who are habitually subjected to the influence of air from drains and sewers, which has obtained access to houses, are liable to suffer from headache, febrile disturbance, anæmia, and a tendency to develop a sore throat. Puerperal fever has, in numerous instances, been found to occur in connection with faulty drains, and erysipelas and hospital gangrene are, at any rate, likely to be aggravated in severity should they develop under like conditions. Diarrhœa has also been attributed, from time to time, to drainage defects.

Two diseases must be especially considered in relation to drain-emanations. *Typhoid fever* has been repeatedly ascribed to this cause, but the evidence adduced is not altogether conclusive, and for the most part, the supposed causal relationship was noted years ago, before certain other possible means of spread of the malady had become well recognised. Against such an hypothesis it has been urged that typhoid fever is not common among men who work in sewers, and sewage does not appear to be a particularly favourable medium for the growth of the typhoid bacillus. Again, there has clearly been misconception as to the likelihood of this organism's gaining access to sewer-air. Experiments, however, made by Alessi show that animals exposed to drain air appear to acquire a predisposition to suffer from some specific infection. Thus, of forty-nine rats which were inoculated with typhoid bacilli, and made to inhale sewer-air, thirty-seven died with symptoms described as being characteristic; while of forty-one rats similarly inoculated, but not exposed to sewer-air, only three died. *Diphtheria* is another disease which has been repeatedly attributed to drainage effluvia. While it seems to be clear that sore throat may result from such exposure, and that under like circumstances a person may be rendered more liable to contract diphtheria, there is no evidence to prove that drainage emanations are concerned in transmitting the diphtheria bacillus.

Accumulations of fæcal matter have been held accountable for the production of disease. Experience of well-managed sewage-farms, so far as the subject has been made the subject of inquiry, seems to negative the view that serious risk to health is incurred by living in their neighbourhood.

Winslow and Greenberg exposed guinea-pigs to strong odours and gases from putrefying fæces and found that there was a reduction in the rate of growth during the first week, but the animals soon became accustomed to the odour and attained after two weeks a normal growth.

Delépine, however, could not detect any influence of sewer-air in Manchester either upon the growth curve of cats, rabbits and guinea-pigs or upon their susceptibility to a spontaneous epidemic due to infected food.[1]

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[1] Report of Sewer Ventilation Committee upon the effects on health of the air of the High Street Sewer in Manchester, 1909.

Emanations from polluted streams have apparently produced illness in some instances, an often quoted example of this being that afforded when the Royal Commissioners on Metropolitan Sewage Discharge made a tour of inspection of the Thames immediately below London, in 1884.

The air of graveyards has also been held to menace the health of people residing in the near neighbourhood. The overcrowded graveyards situated in close proximity to houses, which were in common use fifty years ago, probably influenced prejudicially the health of persons living near them ; cholera, in 1849, was, it is said, found to be specially prevalent in the neighbourhood of graveyards, but there is no evidence that injurious effects are produced under the conditions which now ordinarily exist. Exposure to concentrated effluvia in connection with exhumations has, in some instances, been followed by diarrhœa and vomiting, and ill-effects undoubtedly result in consequence of inhaling air, grossly contaminated by products of decomposition from the bodies of men and horses, on battlefields.

Vitiation of Air by Combustion—The burning of coal for heating or manufacturing purposes is an important source of atmospheric impurity. It has been estimated that each ton of coal burnt represents nearly three tons of carbon dioxide added to the atmosphere. Carbon monoxide is also produced in considerable though very varying amounts, according to the degree of completeness of oxidation of the carbon of the coal. In addition to these gases, the burning of coal contributes to the atmosphere aqueous vapour, sulphur compounds, soot and organic matter.

The quantity of sulphur compounds yielded largely depends upon the character of the coal used. The sulphur existing, in one or another form, in ordinary coal, varies from less than 1 per cent. to more than 5 per cent. It becomes converted, on burning, into sulphurous and sulphuric acids, carbon bisulphide, ammonium sulphide, and, exceptionally, into sulphuretted hydrogen, while a certain amount of free sulphur may escape. The presence of sulphur compounds appreciably contributes to the pollution of the atmosphere of districts in which much coal is burnt.

Particles of grit are also added to the air ; flue dust is not taken up by phagocytic cells in the lining of the alveoli of the lungs and is a dangerous dust to inhale. The smoke pall over cities reduces sunlight and removes the germicidal actinic rays. The average percentage loss for twenty years of monthly duration of bright sunshine in the Cities of London and Westminster as compared with more rural places was 38 and 36 respectively, reaching as high as 83 in the City of London during December. Cohen and Ruston found that the intensity of diffuse daylight in the centre of Leeds was 40 per cent. less than in the outskirts. The potency of sunlight for healing has of recent years led to the belief that it must also play an important direct part in the maintenance of health. The cutting off of the radiant energy of the sun and the hindrance to the evaporation of water increases the cold humidity of the climate and impels people to remain indoors instead of taking healthy exercise in the open air.

The deposit of soot on leaves and the presence of free acids in the air[1] has a detrimental effect on vegetation, interfering with the supply of fresh green vegetables to towns and increasing the cost of milk production. Domestic soot is more destructive than factory soot owing to the higher percentage of tar present. Bituminous, or more correctly "humic"[2] coal, produces more tar than anthracite.

Comparisons of the mortality rates for respiratory diseases of individual industrial towns (Bolton and Warrington) with more residential towns (Northampton and Reading), show an excess by 72 per cent. in the towns with the more smoke-laden atmosphere. Although several factors may contribute to the lower mortality rate of rural districts from respiratory diseases—13 per million as opposed to 35 per million in cities—yet the smoke must play an important part in the difference.

The particles of unconsumed carbon given off from numerous chimneys, interfere, more or less, at all times, with the comfort of dwellers in towns; they not only add enormously to the total amount of dirt which requires more labour for its removal, but they are a hindrance to the free ventilation of dwellings. They make their presence especially felt under circumstances in which there is little movement of air either in the form of wind or upward convection currents, while coincidently the atmosphere becomes misty from excess of moisture, a condition of things which is, of course, especially likely to be developed during fair weather with low temperatures.

Condensation of aqueous vapour begins upon particles of various hygroscopic substances present in the air, one of the most important of which is sulphur dioxide; when the droplets of moisture are formed, they absorb the carbon and dust particles present and become black, producing an opaque medium which shuts out the light of the sun, in fact, what is known, from the place of its typical development, as a London fog. In such an atmosphere sulphurous acid often makes its existence distinctly felt, producing irritation of the conjunctiva, and of the mucous membrane of the lungs. In the continued absence of wind, and in the presence of the other favouring atmospheric conditions, such fogs may last for days, and, under these circumstances, the death-rate, more particularly from diseases of the organs of respiration, is usually materially affected.

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[1] The iron pyrites associated with many of the coal-seams gives rise to sulphuric acid, which attacks the limestone blocks of buildings beneath their accumulated sooty crust.

[2] See E. A. N. Arber, "The Natural History of Coal."

During a period of fog in London between January 24 and February 7, 1880, the death-rate rose from 27 to 48; in 1892, after a fortnight of fog, it rose to 42.[1] In the burning of wood, a far smaller amount of sulphur compounds is produced than in the combustion of coal. Charcoal fires yield, however, considerable quantities of carbon monoxide.

The production of smoke in manufacturing districts can be largely controlled by regulation of stoking operations in factory furnaces.

The incomplete combustion of the fuel is due to the cooling of the vapour or gases produced below their ignition point (1100–1250° F.) before they are completely burnt, or to there being either insufficient air at the right place and time or inadequate mixing of air and gases.

Much depends upon the care the stoker is willing to exercise; the addition of coal in small quantities at short intervals tends to obviate the production of dense black smoke.[2] Mechanical stokers have been found useful in this connection; in some appliances the object aimed at is to spread the fuel evenly over the fire; in others, the fresh fuel is heated before being gradually delivered to the fire bars, and the smoke arising from the newly-added material has to pass the hottest part of the fire before it escapes to the flue. The use of forced draught is also an important means of promoting smoke-consumption, by rendering combustion more complete. Excellent results are obtained by employing the steam-blast.

The Smoke Abatement Bill of Lord Onslow extends the provisions of the Public Health Act, 1875, relating to smoke nuisances, produced by chimneys other than those of private dwelling-houses, by making them *apply to smoke that is not* "*black smoke*," and by including soot, ash, grit, and gritty particles under the term "smoke."

Urban authorities and the London County Council would have power to make bye-laws requiring the provision *in new houses* other than private dwelling-houses of such arrangements for heating as are calculated to prevent or reduce the emission of smoke.

The Departmental Committee on smoke and noxious vapours abatement, 1920, recommended that the Minister of Health should be empowered to fix standards from time to time as regards the nature and quantity of smoke allowed to be emitted from factory chimneys. The standard most commonly adopted at present is three minutes' black smoke in an hour. The London County Council allow a period of grace, five minutes from the lighting of the furnace, but hold that after this a discharge of black smoke for one minute or over is an offence. In Sheffield the standard is adapted to the number of boilers in use; for one boiler, two minutes' black smoke is allowed in an hour; for two boilers, three minutes; for three boilers, four minutes; for four or more boilers, six minutes.

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[1] From a statistical inquiry extending over 27 years and dealing with a population of about 500,000 people (in Islington and St. Pancras), W. T. Russell concluded that fog alone causes no increase in the number of deaths, but when associated with a low temperature and frost brings about a marked increase in the respiratory death-rate of adults. See "Lancet," August 16, 1924, p. 339.

[2] See Clinch's card of instructions to stokers (H. K. Lewis).

The smoke produced by domestic chimneys has been held responsible for some two-thirds of the total amount of smoke present in the atmosphere of towns; smoke emission from these chimneys is not controlled by legislation. The radical measure, the adoption of central heating, is only very gradually being effected; gas fires are, however, much more largely used of late years. A more extended use of coke would result in less smoke; special coke stoves are now made which are claimed to be suitable for cooking, heating water and warming the house.[1] The problem both of factory and domestic smoke would be largely solved by the discovery of a suitable process for the low-temperature carbonisation of coal.

Impurity is contributed to the air by *artificial lighting.* Coal gas is produced by the destructive distillation of coal, in retorts, in the absence of air. The residue is called coke; the volatilised products are collected and passed through condensers in which the tarry matter, and some of the ammonia, are deposited on cooling, then through scrubbers, in which the products are thoroughly exposed to the action of water, and ultimately into purifiers containing lime and oxide of iron for the purpose of removing sulphur compounds and carbon dioxide. The gas so produced contains about 50 per cent. of hydrogen, some 33 to 36 per cent. of marsh gas, 6 to 7 per cent. of carbon monoxide, about 6 per cent. of olefiant gas and other illuminants, a little nitrogen, and traces of sulphur compounds. The Metropolitan Gas Referees prescribe that no sulphuretted hydrogen shall be present, and that the maximum of sulphur compounds, other than H_2S, shall not be such as to yield more than 17 grains—in winter 22 grains—of sulphur per 100 cubic feet of gas, on an average of three days. The permissible amount of ammonia is 4 grains per 100 cubic feet.

The gases to which the illuminating properties of coal gas are principally due are olefiant gas, and other non-saturated hydrocarbons. The main volume of gases is constituted by what are termed carbon dioxide diluents, while nitrogen and the sulphur compounds are spoken of as impurities.

Water gas is made by blowing a current of steam through incandescent coke or coal. The water is split up into its elements and the oxygen combines with the carbon to form carbon monoxide. To make the flame luminous it is enriched in a carburettor with vaporised petroleum, *i.e.*, hydrocarbons are added. Water gas contains about

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[1] See "The Smokeless City," Simon and Fitzgerald, p. 47.

30 per cent. of carbon monoxide. In this country it is not often used as an illuminant by itself, but a certain proportion is very commonly added to coal gas. When gas is burnt, the hydrogen and hydrocarbons are consumed, and the main impurities added to the atmosphere are carbon dioxide and water vapour; there are, moreover, traces of sulphurous acid and ammonia, and, if the combustion is not perfect, appreciable amounts of carbon monoxide.

Escape of gas within dwelling-houses, apart from risk of explosion, is attended by danger, by reason, mainly, of the contained carbon monoxide, though it has been suggested by Corfield that cases of sore throat, observed in association with slight escapes of coal gas from defective fittings, are attributable to sulphur compounds contained in the gas. The main impurities which have to be reckoned with when gas is burnt in rooms, under ordinary conditions, are carbon dioxide and aqueous vapour, the amount of carbon monoxide being insignificant with fairly perfect combustion, and the quantity of sulphurous acid very minute.

The illuminating power of gas is gauged by comparison with the lighting capacity of a sperm candle burning 120 grains per hour. An ordinary bat's-wing burner, of 16 candle power, consumes 5½ cubic feet of gas per hour, and has been estimated to produce, in that time, 2·8 cubic feet of CO_2, and 7·3 cubic feet of moisture, thus rendering the air impure to about the extent to which it would be vitiated by the processes of respiration of five adults.

An ordinary sperm candle of "one candle power" yields, on complete combustion of its 120 grains, about ·4 cubic foot of carbonic acid, and nearly the same amount of water. In the case of oil lamps burning paraffin, the quantity of oil used per candle power ranges from about 62 grains per hour upwards, according to the class of lamp employed, with production of about ·28 cubic foot of carbon dioxide, and ·22 cubic foot of aqueous vapour, these amounts being proportionately increased, in the poorer sorts of lamps, according to the quantity of oil consumed. From the data given above, it may be calculated that to produce a 16 candle power light, ¼ lb. of sperm candles (equivalent to rather less than ⅓ lb. of ordinary tallow candles), rather more than 2 oz. of paraffin, or 5½ cubic feet of gas, must be consumed per hour; the amounts of CO_2 produced would be 6·4 (about 7·3 in the case of tallow candles), 4·5 and 2·8 cubic feet respectively; the vitiation of air would correspond to that caused by 11 or 12 adults in the case of sperm and tallow candles, 7½ adults in the case of paraffin, and 5 adults in the case of gas. In the combustion of candles and oil no sulphur compounds are produced; oil lamps yield, however, an appreciable amount of organic matter to the air of the room in which they are used.

By employment of the electric light the addition of impurity is altogether obviated, and no oxygen is abstracted from the atmosphere.

The use of the incandescent gas mantle has radically influenced the comparison of the relative hygienic advantages of gas and electricity for illuminants. An investigation by S. Rideal as to the effects of the use of inverted incandescent burners and electric glow lamps on the atmospheric condition of two rooms and their occupants showed that although gas burnt in this manner originally developed more heat than the electric light the gas burners gave rise to stronger air currents and rapidly removed not only the products of combustion but also the exhalations of the persons present. The ascending currents of air from the gas light on reaching the ceiling rapidly parted with their heat which was conducted away by the rafters and joists. The heat production of a 25 candle power gas lamp was 691 British thermal units per hour, the moisture production in grains 506, the carbon-dioxide production 0·77 cubic feet. The heat produced by a 25 candle power electric lamp was 329 British thermal units per hour, much more heat than is commonly supposed. For these reasons the temperature of the room was the same when either gas or electricity was used. No alteration of the relative humidity of the air (70 to 75 per cent.) occurred during the use of either illuminant.

The bacterial contents of the air of the rooms were less with gas than with electricity owing to the burning up of the organisms in the gas flames and the sterilising effect of the sulphur acids from the gas : the increased condensation on the surfaces removed organisms together with sulphur products. As a consequence the condensed moisture produced in the gaslit rooms was sterile ; that in the electric-lit rooms contained a number of living organisms. The experiments established that the products of combustion of gas, *viz.* heat, carbon dioxide, and moisture so far as they modify the health of the occupants of a room, are derived from the inmates more than from the illuminant and that a room of moderate size can be efficiently lighted by gas without sensibly affecting the amount of these three factors.[1]

Vitiation of Air by Respiration—While inspired air yields only about ·04 per cent. of carbon dioxide, expired air contains about 4·1 per cent., some four volumes per cent., roughly speaking, of carbon dioxide having been added, while a corresponding, though very slightly greater, amount of oxygen has been abstracted from the air. The volumes of nitrogen in expired and inspired air are practically identical, 79·4 in expired, and 79·00 in inspired air ; but expired air is saturated with water vapour, while inspired air usually falls considerably short of the point of saturation ; again the amount of organic matter in expired air is also increased as compared with that in the normal atmosphere. It remains to note that while the volume of the expired air will be seen, from the above statement, to be about $\frac{1}{50}$th less than that of the air inspired, this result rests upon the assumption that the volumes are calculated at the same temperature and pressure ; the fact that the expired air is warmed more than compensates for the loss above referred to, and the air exhaled actually occupies a volume about $\frac{1}{9}$th greater than that of the air inspired.

In ordinary quiet respiration some 22 cubic inches of air, containing 4·4 per cent. of CO_2, are exhaled eighteen times, or thereabouts, per minute. This would yield ·6 cubic foot per hour. Much depends upon the size and activity of the individual, but the amount given is usually taken as indicating the quantity contributed to the atmosphere per hour by the average unit of population.

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[1] S. Rideal, " Relative hygienic values of gas and electric lighting," " Journal of the Royal Sanitary Institute," March, 1908.

Now, the atmosphere normally contains ·4 part of carbon dioxide in 1,000 parts. If, therefore, the average individual breathed into a space containing only 1,000 cubic feet of fresh air, the amount of CO_2 present would, at the end of an hour, be ·4 + ·6 cubic foot, *i.e.*, ·1 per cent. If he breathed into a space containing 2,000 cubic feet, the amount would be ·4 + ·3 cubic foot in each 1,000 cubic feet, or ·07 per cent. ; and if the space contained 3,000 cubic feet, the amount would be ·4 + ·2 cubic foot in each 1,000 cubic feet, or ·06 per cent. The amount of CO_2 over and above that present under normal conditions in the atmosphere, is spoken of as the " respiratory impurity," and this, in the three cases just mentioned, is seen to be ·06 per cent., ·03 per cent., and ·02 per cent. respectively. It was found by De Chaumont that if the respiratory impurity in a room was allowed to exceed ·02 per cent., a person entering the room, from the outside air, was able to detect by the sense of smell that the air of the room was of different quality from that outside. He therefore fixed the amount ·02 per cent. as that of the " permissible respiratory impurity." To secure this amount not being exceeded, it is necessary to supply 3,000 cubic feet of air per head per hour, and as, in this country, the air of a room can, with ordinary means of ventilation, be renewed about three times an hour without producing draught, compliance with the standard indicated implies the provision of 1,000 cubic feet of air space per head.

It should perhaps be emphasised that the view generally held at this time was not that the carbon dioxide expired was harmful in itself but that the amount of carbon dioxide was an indicator of the amount of respiratory pollution by some other substance or substances whose exact nature was not determined. The Departmental Committee on Ventilation in Factories distinguished between carbon dioxide of respiratory origin and that produced by illuminants by advising a maximum limit of 12 parts of carbon dioxide in 10,000 in the daytime when the excess above that found in the external air is chiefly due to respiration, and permitting 20 parts after dark in places where gas or oil is used for lighting.

The air of occupied rooms is also rendered impure by the passage of volatile substances usually derived from the persons and clothing of the occupants. These objectionable smells are notoriously increased when there is any failure as regards washing of the person or dirty clothes are worn.

Some animals contribute more carbon dioxide to the atmosphere than human beings, and it might perhaps be anticipated that in crowded stables and cow-sheds the worst results, as regards carbon dioxide, would be recorded. Oxen and horses give off about three times as much carbon dioxide as a man does, and, in many cases, no more than 600 to 800 cubic feet of space per animal are provided, hence the extent to which carbon dioxide might be expected to accumulate is considerable. Carbon dioxide determinations for stables require, however, to be carried out with due correction for the amount of ammonia present, otherwise a less degree of pollution may be estimated than that which really exists, and in practice this source of error does not as a rule appear to have been allowed for.

The production of carbon dioxide and absorption of oxygen in animal respiration are compensated for by the fact that vegetable tissues, and particularly green leaves exposed to sunlight, take up carbon dioxide from the air, assimilating the carbon, and giving off oxygen. Thus the tendency to accumulation of carbon dioxide and diminution in amount of oxygen which results from the existence of one form of life, is corrected by the carrying on of processes of an opposed character by other living tissues.

Recent observations have all gone to show that the excess of carbon dioxide likely to be attained in ill-ventilated and crowded rooms does not act as a poison. The amount of carbon dioxide in the alveoli remains more or less constantly at about 5 per cent. of an atmosphere, and the rate and depth of breathing are so regulated as to maintain this percentage. This is accomplished by the respiratory centre in the medulla. The carbon dioxide in the air can only reach dangerous proportions in a hermetically sealed chamber. In the worst ventilated theatres, etc., this gas is not present in a higher proportion than 1 per cent. ; rarely is it above 0·5 per cent. Men in breweries work for years without disadvantage to their health in places where the carbon dioxide may be 1–2 per cent. ; in submarines the men are willing to remain submerged until the carbon dioxide reaches 3 per cent. In a respiration chamber a man remained with comfort for twenty-four hours in an atmosphere containing 220 parts per 100,000 of carbon dioxide. When the percentage of carbon dioxide rises over 3 per cent. hyperpnœa begins to be troublesome and there may be slight headache ; on breathing 5–6 per cent. the hyperpnœa is exhausting, sweating and headache occur ; an atmosphere containing 10 per cent. can be endured only for a minute or so, dimness of vision and tremors occur.

The change in oxygen content of crowded rooms is not sufficient to produce ill-health. "Analyses show that the oxygen in the worst ventilated schoolroom or public meeting-place is never lessened by more than 1 per cent. and very rarely as much" (L. Hill). In noted health resorts in the Swiss mountains the barometer stands at such a height that the partial pressure of oxygen is less than in the most ill-ventilated room at sea-level.

Although it is possible that a poison is present in expired air, the experimental evidence of Brown, Séquard and Arsonval, which is largely responsible for the widespread belief of the presence of organic poisons in expired air, has been destructively criticised. They found that water condensed from the breath when injected into animals acted as a poison. It is thought that the condensation water may have contained bacteria; in some of the experiments the quantity of water injected was so large as to have in itself a disturbing effect on the animal. Condensation water obtained from experiments with a man in a respiration chamber when injected subcutaneously into white rats proved to be non-toxic. Another often quoted experiment showed that animals died from poisoning when confined in chambers through which air was drawn from a series of other chambers containing animals so that expired air was inhaled. But other observers repeating the experiments showed that if the oxygen is not allowed to sink to limits incompatible with life or the carbon dioxide to rise to a poisonous proportion, the animals remain in good health.

The view which at present receives most support is that the ill-effects of inadequate ventilation are due to interference with the removal of heat from the body. The quantity of water given off from the lungs of an individual in twenty-four hours amounts roughly to some 10 oz., and about twice this quantity is given off by the skin. The increased temperature and excessive amount of moisture in air vitiated by respiration, are factors which are largely responsible for the feeling of discomfort experienced in crowded rooms. The removal of heat from the body is materially interfered with under conditions of the kind in question, and an atmosphere polluted by respiration is likely to prove oppressive from this cause alone.

The human body is usually warmer than its surroundings and like any other warm body gives off heat to these surroundings by conduction, radiation and convection. A further mode of loss of heat is by evaporation of the sweat. Heat loss is nearly entirely dependent on the condition of the air; if the air is warmer, the loss is less rapid than when cool; if it is humid the evaporation of sweat is less active than when it is dry; if it is stagnant, the loss is less rapid and evaporation slower than if it is moving.

Hill ascribes the effects of defective ventilation to the absence of movement of air of suitable temperature and humidity. In practice the air movement advocated entails changes of air in the room. The amount of air movement required can be determined by means of the kata thermometer, an instrument designed to measure comparatively and approximately the rate of heat loss of the body under varying conditions.

The bulb is dipped into warm water until the alcohol rises just to the safety reservoir ; the instrument is then placed in the air to be tested and the time the alcohol takes to fall from 100° F. to 95° F. (*i.e.* through 2½° above and below the normal body temperature) is observed with a stop watch. By this means the amount of heat lost by radiation and convection is ascertained. But the human body, which is practically always sweating, also loses heat by evaporation and resembles a wet-bulb rather than a dry-bulb thermometer. The kata thermometer is therefore also used wet ; a muslin glove is passed over the bulb before it is dipped into the warm water. The instrument so used gives the cooling power by radiation, convection and evaporation ; the difference between the rates of cooling of the instrument used dry and wet represents the cooling due to evaporation and enables us to measure the physiological efficiency of air movement.

Each instrument, owing to slight differences in such items as size of bulb and thickness of glass, possesses a "factor" of its own for which allowance has to be made before readings can be compared ; this standardising factor is stated on the stem. The factor divided by the number of seconds the kata thermometer takes in cooling from 100° F. to 95° F. represents the standard cooling power, *i.e.* the heat loss in milli-calories per square centimetre per second.

The kata thermometer has proved useful in determining the amount of air movement required in workshops where the supply of moving air is especially necessary ; every hindrance to heat loss either diminishes bodily exertion or causes the exertion to be done under a feeling of depression and weariness. Again, energy which should be devoted to muscular work is wasted when it is diverted to cooling the body by sweating. Experience has demonstrated that comfortable conditions are represented if the standard cooling power of the dry kata is not less than 6 when sedentary work is pursued, and not less than 7 for work involving medium physical exertion, and that the wet kata cooling powers for such occupations should be not less than 18 and 20 respectively.

The superiority of the kata thermometer over the dry and wet bulb thermometer for the purpose is shown by the following record of the examination of two work-places ; the dry and wet bulbs readings are almost identical, but the wet and dry kata-thermometer readings bring out differences of physiological importance.

	Temperature in degrees Fahr.		Cooling powers.		
Place.	Wet bulb.	Dry bulb.	Wet kata-t.	Dry kata-t.	Evaporative power.
Brass foundry (good) .	60	72	24	7·3	16·7
Machine shop (bad) .	61	72	15	4·6	10·4

These views on the influence of physical conditions of the atmosphere on the body have been applied to explain the beneficial effects of open air and the deterioration in physical well-being produced by moist heat. The effect of open air is held to be due to stimulation of the nerve endings in the skin, which originate by far the largest group of impulses constantly affecting the central nervous system. A cold skin depleted of blood is an incentive to muscular activity which requires the concomitant diversion of the blood stream to the muscles and deeper structures. Outdoor conditions provide a ceaseless variation in the rate of cooling, evaporation, absorption of radiant energy, which relieves us from monotony, stimulates tone and metabolism. Indoors the conditions are generally uniform, monotonous and unstimulating. In closed artificially-heated rooms, cooling and evaporative powers are very greatly reduced by the lack of the vastly freer ventilation which obtains out of doors even on calm days.

Haldane and others have found that the body reacts to the effect of temperature as recorded by the wet-bulb thermometer, *i.e.*, to the capacity of the air to absorb moisture. Until the wet-bulb thermometer registers about 78° F. the human body is able to regulate its heat loss by lessening or increasing the flow of blood through the skin and causing a corresponding decrease or increase in the secretion of sweat. At this wet-bulb reading unless work is stopped the body temperature rises steadily. At about 88° F. wet-bulb, even at rest, the body temperature rises steadily and it is impossible to remain long in such air.

Long before these upward danger limits of wet-bulb temperatures are reached the effect of warm humid atmospheres on the body is considerable. Much attention has been directed towards the deterioration of physique which obtains in the textile industries and especially among cotton weavers. The explanation of this deterioration given by Pembrey and Collis is that " During work, if the air is hot and moist the worker must send more blood to the skin to be cooled and must sweat in order to prevent his temperature from rising too high. Hot moist air is not favourable for cooling of the blood or the evaporation of sweat. Muscular work by creating the need for a larger and faster supply of blood to the muscles increases the rate of the heart's action ; if, at the same time, more blood must be sent to the skin to be cooled then an extra amount of work must be done by the heart. The regulation of the distribution of the blood is effected by the nervous system. A warm skin diminishes the tone of the muscles, lowers the metabolism in the body and produces a decrease in appetite ; the natural tendency is for the nervous system to become less active and for muscular work to be diminished. In a factory weaving shed, however, the machine sets the pace and the worker must neglect the dictates of his sensations which are the natural guardians of his health and well-being. He must strive as far as possible to accommodate himself to the adverse conditions of heat and moisture. Some workers can respond to the demand better than others, but all must have their powers of accommodation taxed when the temperature of the wet bulb rises much above 70° F. It is not surprising, therefore, that at the end of a day's work many of the weavers complain that they have no energy left, have no great desire for food, and need only drink and rest. As a class, the weavers appear to be small in stature, spare in build, thin in the face, pale in complexion, and have a wearied look. Many of them complain that their appetites are poor and require tempting and that they suffer from indigestion. That these conditions are due to the prolonged exposure to the effects of the warm moist atmosphere in which the weavers work is shown by their absence in outdoor workers of either sex, or in weavers of jute, which does not require a humid, moist temperature, who may earn far less wages and be housed much worse, or in other workers in other industries in Lancashire."[1]

Legge found that factory hands with temperatures of 100° F. and over (taken in the mouth) had an average pulse rate of 101 and respiration rate of 23 as contrasted with 89 and 20 respectively in the case of similar workers with temperatures of 99° to 99·9° F.; these differences operating for years throw a heavy tax on the economic working of the body and go far to explain the defective physique of the cotton worker.

Kinloch suggests that the differences between fresh and vitiated air might in part be explained by the fact that enclosed air does not contain the radioactive substance present in fresh air.[2]

Although we are uncertain as to the exact cause of the ill-effects of breathing air vitiated by respiration there is no doubt that the consequences are serious. In catastrophes, such as that of the Black Hole of Calcutta, or that which befell the steerage passengers of the "Londonderry," who were shut down in the cabin, in 1848, during a storm, the victims were apparently packed almost as closely as standing room would permit. The symptoms in these cases are said not to have been those of simple asphyxia, inasmuch as among persons recovering from the immediate ill-effects fever, accompanied by evidence of affected nutrition, was observed. In instances in which less extreme crowding occurs, but in which vitiated air is breathed for some time, headache, a sense of oppression and discomfort, slowing of the heart's action, quickening of respiration, and in some cases nausea are apt to supervene.

If the exposure to the polluted atmosphere be habitual, anæmia, loss of appetite, impairment of nutrition, and pulmonary disease, particularly phthisis, may possibly be developed.

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[1] Departmental Committee on Humidity and Ventilation in Cotton Weaving Sheds. Second Report, Cd. 5566, 1911.

[2] See "British Medical Journal," p. 356, August 26, 1922.

In such cases the question of the influence of the vitiated air is complicated by the fact that other causes likely to aggravate, if not to produce, the observed effects are often coincidently at work. Thus persons who breathe day after day polluted atmospheres such as those now in question, are usually engaged in sedentary employment, and often work long hours and inhale not only the products of respiration, but also products of combustion (their work frequently necessitating the use of artificial light), and in addition, it may be, certain dusts or vapours evolved in connection with the particular work upon which they are engaged. As to the dependence of the symptoms exhibited, in large part, upon the inhalation of impurity produced in the process of respiration, there can, however, be no question. The evidence, for example, of the relation of phthisis to the breathing of the air of crowded rooms is of quite unmistakable import.

Observations in Dundee made by Carnelley, Haldane, and Anderson, show that phthisis tends to prevail where overcrowding exists, and somewhat similar results have been recorded with reference to crowding of population upon area in various parts of London and other large cities. Again, the excessive incidence of phthisis in correspondence with prevalence of the back-to-back system of house construction has important bearing in this connection, inasmuch as purity of air in the dwelling room is much influenced by ventilation as well as by the amount of cubic space provided. This question will later be further referred to.

In such instances it might, however, be argued that other influences, such as poverty, intemperance, and the like, were really the important factors at work. In the case of prisons and of barracks, some of these suggested disturbing influences can be eliminated. The reduction of the phthisis rate in the Army has been especially appealed to as an instance in point. As early as 1858 the Royal Commissioners on the Organisation of Military Hospitals were led to attach special importance to the subject of overcrowding, and the improvements inaugurated at about that time, as regards cubic space in barracks, have been succeeded by a diminution of the phthisis rate in the Army, markedly exceeding the diminution which has occurred in the civil population. Overcrowding had been specially marked among the foot guards, and in them the phthisis mortality during the years 1837–46 reached the excessive amount of 11·9 per 1,000 of strength. In the seven years 1864–70, it is interesting to note that it had fallen to 2·3 per 1,000. The mortality from phthisis in the Army at the present time is slightly below that of the male civil population at the same ages, whereas fifty years ago it was in notable excess of that amount.

A very striking instance of the power of disseminating infection displayed by the virus of tubercle under circumstances favourable to the spread of the disease is afforded by the researches made by Cornet concerning the Catholic nursing institutions of Prussia. Dealing with the twenty-five years preceding 1888, Cornet found that in these institutions the deaths from tubercle alone amounted to 62·88 per cent. of the total deaths, a percentage considerably in excess of that which might have been anticipated in women of the ages under consideration. He found, moreover, that tuberculosis was most deadly in the third year of cloister-life, and he concluded that "a healthy person of twenty-five years of age, who then begins cloister-life, and the work of a nurse, has an expectation of life equal to that of a healthy woman of the general population who is fifty-eight years of age." (But see Bulstrode Sanatorium Report, p. 63.)

Again, Niven investigated the prevalence of phthisis in seventy-seven Manchester common lodging-houses, with a population of about 1,825 persons; he found that the phthisis death-rate in these persons exceeded 20 per 1,000, while the mortality at ages 25–45 for the whole of Manchester amounted to only 3·95 per 1,000. As further instances of the relationship between phthisis and the breathing of a vitiated atmosphere may be mentioned the frequent occurrence of the disease in animals kept in confinement. In particular, reference may be made to the case of cows crowded together in cow-sheds, as in these animals, under such conditions, the ravages caused by tuberculous disease are specially remarkable.

Lastly, mention must be made of the way in which the spread of other forms of specific disease is favoured by close aggregation of persons. Typhus has often prevailed in association with overcrowding, and measles, small-pox and plague may also manifest a like ability. The evidence which has accumulated in recent years as to dissemination of certain diseases, particularly diphtheria, scarlet fever, and measles, in school classrooms, is quite conclusive as to the risk incurred by bringing a number of children together within a confined space, unless precautions are undertaken to detect and exclude sufferers from these maladies. The diseases which spread in hospital wards must also be mentioned; outbreaks of hospital gangrene and erysipelas are for the most part things of the past, now that the importance of preventing their occurrence is recognised; various sorts of sore throat are still, however, of common occurrence as a result of exposure to the atmosphere of hospital wards.

VENTILATION AND WARMING

The great problem of ventilation is to secure as far as practicable—and usually the main difficulty is the limited amount of cubic space per head available—sufficient interchange of air without production of draught, *i.e.*, air moving at a rate of more than 5 feet per second. A great deal depends upon the original plan of construction of the particular building in question; if a house has ample open space about it, and if regard has been paid, in planning the arrangement of rooms, to the need for preventing stagnation of air, the problem is a comparatively simple one. This aspect of the question may be best considered in connection with the subject of the dwelling in its relation to health, to be presently dealt with. If the rooms to be ventilated are those of a house constructed at a time prior to the coming into force of adequate building regulations, or of one situated in a locality where no such regulations are in force, the matter becomes one of exceptional difficulty. If, again, the rooms, the ventilation of which has to be provided for, are to be occupied in such a way as to only allow a very limited amount of cubic space per individual occupier, special effort will be needed to combat, as far as possible, the defects of original design, and the result at best is likely to be far from satisfactory.

For ideal ventilation of a room the requirements are:—

(*a*) Equable temperature, 60° to 65° Fahr.

(*b*) Moderate relative humidity or moisture contents, 60 to 75 per cent.

(*c*) Air movement which, though not sufficient to be felt as objectionable draught, yet continually removes and replaces the vitiated air, surrounding the body with fresh air, thus assisting the natural action of the pores of the skin and stimulating the nerve tissues (velocity of 1 to 3 feet per second).

(*d*) Clean air, *i.e.*, free from the suspended impurities prevalent in large cities, and near busy roads—dust, insects, oily vapours, from gasoline engines, soot, etc.

(*e*) Freedom from insanitary or objectionable odour. In rooms where the glass and wall exposure is considerable, ventilation for the removal of bodily heat need not be considered except when the apartment is to be artificially cooled. In crowded audience halls, and even in schoolrooms, it is the determining factor.

Mechanism of Ventilation—The diffusion of gases, the action of winds, and variations of barometric pressure, all tend to cause interchange of air, and removal of impurity; in the case of rooms provided with suitable inlets and outlets, advantage may be taken of these natural agencies in promoting efficiency of ventilation; and still more effectually, the movement of the air caused by difference of temperature, or that induced by the aspirating effect of a current of air blowing across an opening, may be utilised to good effect in replacing contaminated by pure air. When ventilation is promoted in this way, by utilising forces existing in nature to the best advantage, reliance is said to be placed upon natural ventilation. When the difficulties to be dealt with are formidable, however, and natural ventilation will not suffice, ventilating fans, blowing machines, steam jets, and the like, may need to be employed to secure adequate interchange of air, and when such appliances are used, the ventilation is said to be artificial. The part played by diffusion of gases in ventilation is most important, but reliance cannot be placed upon diffusion alone, even for securing the free dilution of gaseous impurity, and for promoting the removal of solid particles it is inoperative.

The action of wind is of importance, not only as regards the space about dwellings, but, owing to the influence exerted even through solid containing walls, in connection also with the movement of the air of rooms; but winds are so variable in force as to make their action as aids to ventilation unreliable under any circumstances, and great difficulty is experienced in regulating their influence so as to prevent draught. Cowls turned towards the wind are sometimes used, and such means are especially adopted in the ventilation of ships. As instances of the utilisation of wind as an agency for ventilating houses, reference may be made to the extraction ventilator (for example Boyle's ventilator), in which the wind effects extraction of air by blowing over the mouth of a ventilating shaft, and to Banner's cowl, in which the opening of the ventilating shaft is caused, by means of a vane, to face away from the wind.

NATURAL VENTILATION—In rooms reliance is mainly placed, as a rule, upon the movement caused by differences of temperature of the internal and external air. The effect of a difference of temperature is considerable; in a weaving shed with an inside temperature 18° F. above that outside, the ventilation was about three times as great as when there was no difference.

The way in which the ordinary chimney comes to act as an outlet for foul air, by reason of the differing weights of columns of air at different temperatures, has been already considered. In summer time, when fires are not lighted, the air in the chimney may be actually colder than the air outside, and the chimney will then act as an inlet, a fact which accounts for the "flue smell" sometimes observed in dwellings under such circumstances.

Down draughts are due to the following causes:—

1. The perflating action of the wind forces air down the outlet.

2. The air in the outlet becomes cooled by its passage through a tube or chimney exposed to the action of the colder external air or by the evaporation of air falling into the outlet.

The passage of air up the chimney is delayed until the air in the outlet has become warmed.

3. When a fire is lighted in a room a current of air passes up the chimney; to supply its place air is drawn into the room; if sufficient outlets from the external air are not provided air will be drawn into the room from the colder rooms of the house *via* the staircase—the chimneys of these rooms will act as inlets.

If a fire be lighted in the colder room for some time the smoke will have difficulty in ascending the chimney ; if, however, the doors of both rooms be closed and the windows opened each room will have a separate inlet and the fire will burn brightly.

4. If one of the outlets of a room has a greater discharge than the others the current in the rest of the outlets is reversed.

An ideal is that the flues should all be of the same height and should have the same exposure to sun and wind.

Assuming that the external air is colder than that in the room, it is obvious that, apart from the action of wind, interchange of air will take place through any window or other opening, the denser outer air tending to descend into the room, and the lighter internal air to ascend, and in part escape into the outer atmosphere. It is a common practice to establish openings in the wall of a room at suitable points in order to give opportunity for such interchange of air to take place.

ARRANGEMENTS FOR VENTILATION

Inlets, as a rule, should be smaller, but more numerous, than outlets, and they should be distributed in different parts of a large room, in order to prevent stagnation of impure air ; the current of entering air should be given such a direction, or be so dealt with, as to prevent draught. *Primâ facie,* inlets should be near the lower, outlets at the upper part of a room, but where artificial heat is in use, and under other special circumstances, considerable modification of this principle is necessary. The air exhaled is driven downwards in expiration, and its natural tendency to rise may be advantageously combated, in some instances, by the promotion of the downward movement, the impure air being then drawn off at a low level; this system is sometimes adopted in places of assembly where people are congregated in groups at one and the same level. In hospitals, on the other hand, where people are lying in bed, and the expired air is directed upwards, there is advantage in encouraging this upward movement by arranging for the provision of inlets, for warmed air at a low level.

Even in the absence of special inlets sufficient air as a rule gets into the room through ill-fitting window sashes or under doors ; and even where these crevices are tightly closed, a certain amount of air manages to get in through walls. This amount is increased if a wind is blowing but lessened if a large proportion of the " wall " space consists of tightly glazed window glass or if the walls are painted so as to be practically air-tight. When all the openings were closed in a room of 1,400 cubic feet with a boarded floor above and only one outside wall the draught in the chimney in spite of the absence of any appreciable wind was found to effect a rate of air change of once in every three to five hours.[1]

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[1] See Departmental Committee's First Report, 1902, on Ventilation of Factories and Workshops.

Small rooms have an advantage in this respect over large ones in that they possess a proportionally larger area of "wall" surface. The surface increases as the square, and the capacity as the cube, of any corresponding diameter for rooms of the same shape. For example, an increase of eight times in the capacity will correspond to increase of only four times in the surface. Very large rooms when unprovided with openings for ventilation may therefore contain very foul air, although the air space per person is very large.

The force of the winds has a marked effect on the exchange of air through walls; an impermeable roof interferes very considerably with the rate of change of air. The effect of the cool glass of closed windows should be noted. Warm air coming in contact with the glass kept cool by the outside air is cooled, becomes heavier and falls to the floor. In this way a steady circulation of air occurs. In modern factories the sides of which are formed of large windows this influence upon the movement of air in workrooms is considerable and does much to prevent the air becoming stagnant.

Inlets and outlets should not be so situated that the incoming air is enabled to immediately escape without mixing with the air of the room. The cooling effect of windows is a factor which requires to be reckoned with in assembly rooms with ample window space; it has been suggested that having regard to the influence exerted in this way upon circulation of air, inlets for warm air should be inserted just beneath each window.

Determination of the relative sizes of inlets and outlets mainly depends upon the rate of flow desirable in the case of the several currents of air. The fact that the impure air, being warmer, will occupy more space really has but little influence in the matter, as the increase of volume corresponding to the higher temperature is not, generally, so great as to exert material effect. As a rule the inflowing current should have less velocity than that of the outgoing air, unless the pure air from without is warmed before it enters the building; if, therefore, cold air is introduced, it would follow that the area of the inlets should, if anything, exceed that of the outlets. It has been suggested that the total inlet area should be fixed so as to provide about twenty-four inches per person, and that each individual inlet should be adapted to the air requirements of two or three persons, while the total outlet area should be equivalent to the total inlet area, but made up of somewhat larger individual outlets, each adapted to the air requirements of about six persons.

A useful inlet could easily be provided where sash windows are used by increasing the height of the lower sill of the window by three or four inches. The bottom sash can be raised a corresponding height without forming an aperture at the bottom of the window. Air can ascend between the upper and lower sashes of the window and enter the room with an upward direction. (Hinckes Bird.) A board nailed across the lower part of the window allows of the same effect being produced. Holes bored in a vertical direction through the bottom sash of the upper window also serve as fresh air inlets which do not cause a draught.

Double windows serve a useful purpose in aiding ventilation in bedrooms, inasmuch as the outer window can be left open at the bottom, and the inner one at the top, and interchange of air is thus secured without any risk of draught.

Simple appliances to serve as inlets are often provided; Tobin's tubes and Sheringham's valves are perhaps most commonly used. They are best placed in corners of rooms farthest from doors and fireplaces.

Tobin's tubes are vertical tubes 4–6 feet high, connected with an air-grid in the outer wall; they can be put out of action by turning a handle which places a shutter across the tube.

Sheringham's valves consist essentially of a sloped plate hinged at the bottom with sidepieces; a cord is attached which, passing over a pulley, carries a weight and allows of the partial or complete closure of the valve. Both these forms of apparatus require cleansing; much dirt and dust are deposited from the entering air; if this is allowed to remain the fresh air supply is contaminated.

The building bye-laws of most authorities insist on the provision of an outlet for foul air in rooms not provided with a fireplace. This usually takes the form of an air-grid, a perforated plate of iron (9 inches × 3 inches in the case of an ordinary-sized room) let into the outer wall, the bricks of the wall behind the opening being omitted. As this opening might act as an inlet, in some cases on the inner opening is placed a piece of wood sloping upwards, so as to direct an entering current of air upwards. Sidepieces are added to prevent the air from escaping at the sides and causing a draught. To prevent rain beating in, the vertical spaces are replaced by horizontal slits, which form the spaces between horizontal bars which slope downwards and outwards—any rain

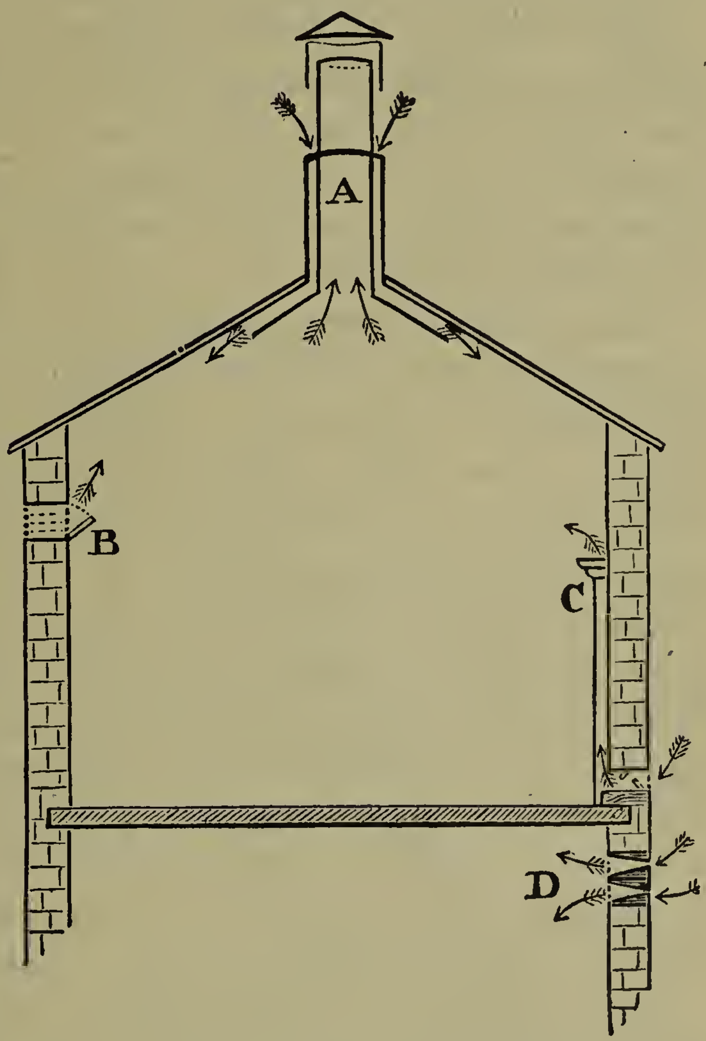

Fig. 13.—Ventilating Openings.
A.—McKinnell's Ventilator.
B.—Sheringham Valve.
C.—Tobin's Tube with Water-Trap.
D.—Ellison's Conical Brick Ventilators.

lodging on the bars runs off towards the outside; each of these sloping bars is called a louvre.

In the case of stuffy rooms about which complaint is made to the landlord, Boyle's valves are occasionally placed on the wall opening into the chimney flue, near the ceiling. They consist of a metal framework, bearing plates of talc hinged at the upper border; they allow of the passage of the foul air from the room into the chimney, but the passage of air or smoke from the chimney into the room is prevented by the talc plate closing the opening.

Air bricks, *i.e.*, bricks perforated with numerous conical holes, having a smaller diameter externally than internally, are often used, the object of the air being made to pass through a channel, the sectional area of which increases on proceeding from without inwards, being to cause the current of incoming air to slacken, and so to obviate draught.

In order to prevent dry-rot of the wood forming the floor of rooms, the space beneath the floor is put in connection with the outer air by means of an air-grid, often made of terra-cotta brick, placed in the outer wall. It also serves as an inlet for the supply of fresh air to a room, the air escaping into the room through the spaces between the boards.

In ordinary living-rooms the chimney generally constitutes the most important means of escape for impure air. The mode of circulation of air commonly observed in such a room is indicated in Fig. 13. In this case no special inlets are assumed to be in use; if they existed, modification of air currents, particularly in their immediate neighbourhood, would, of course, be produced.

McKinnell's ventilator can be used in the case of schools, large rooms, or halls which have no apartment above them.

The gas burners used to light the room are placed under a hood, the central part of which passes up in the form of a tube to the outer air and acts as an outlet; fresh air is admitted between this tube and a larger outer tube surrounding it; the upper surface of the hood serves to direct the flow of air into the room and prevent it being immediately removed by means of the inner tube.

In crowded dormitories it is a common practice to replace one of the panes, of one or more windows, by a perforated piece of zinc; again, louvred glass ventilators are sometimes used. In schools, to obtain sufficient ventilation much can be done by proper arrangement of the windows.

Both for the purposes of ventilation and lighting the windows should be large, the sills should be placed not more than 4 feet above the floor, the tops of the windows should reach nearly to the ceiling so as to prevent stagnation of foul air between the top of the window and the ceiling. Both the top and bottom panes of the window should be arranged to open inward as hoppers.

A hopper is a pane of glass which can swing on hinges placed along its lower side; in order to avoid side draughts two sidepieces are provided.

The fixed hopper used in the Staffordshire type of school is adapted to ordinary sash windows. When the lower sash is raised a glass plate 2 feet in depth, fixed to the window sill close to the window rail, projects into the room so as to leave a space of 9 inches between it and the window; the two end angles are filled in by the frame which supports the plate. In the case of new school buildings the Board of Education advises the removal of foul air by means of separate air chimneys carried up in the same stack as the smoke flues.

The foul air enters the air chimney through an outlet placed near the ceiling of the room; its temperature is raised by the heat imparted from the hot air and gases of the chimney flue and it ascends, passing out at the level of the chimney top. When the fireplace is not used the air present in the air chimney should be warmed by a jet of gas to prevent it acting as an inlet.

Boyle's extractors are much used, especially for older schools, and also on buildings. They are cylindrical in shape, surrounded at their upper end by an attachment with vertical slits so arranged that whatever may be the direction of the wind there will be a current of air blowing through the apparatus having an aspirating effect on the air of the apartment to which it is connected.

ARTIFICIAL VENTILATION

Artificial ventilation may be carried out by extraction of the foul air (extraction or vacuum method), by the supply of fresh air (impulsion or plenum method), or by a combination of both. In the extraction of air heat is often employed as in the case of the ventilating furnaces of mines; rooms to be ventilated are connected by tubes with an air-shaft, the air of which is warmed by a fire, steam, or hot-water pipes producing an upward current.

An alternative, more often seen in factories and schools, is the use of fans for purposes of extraction. They have the advantage of easily regulating the amount of draught by varying the speed of the fans. Of late years the use of fans for ventilating purposes has been greatly extended. The capacity of a fan is stated in cubic feet of air moved per minute and the pressure set up in inches of water gauge. The pressure exerted by moving air in a duct is usually measured by the difference in level of a liquid in the arms of a U-shaped tube, having one end open to the atmosphere and the other end connected to the duct or pipe where the pressure exists. The difference in level represents the height of a column of the liquid which will be sustained by the excess of pressure. Water is used in these gauges when employed in ventilating work.

The Ring type fan is only suitable for handling volumes of air against negligible resistance, *i.e.*, below 0·125 inch static water gauge, at an air velocity of the order of 500 feet per minute. All fans of this type should be fixed so as to discharge or draw air directly from the room in cases where no obstruction is present or no strong aspirating tendencies causing air to be drawn out by another outlet; they are unsuitable for forcing air into or extracting air from long or subdivided flues. In an extraction system where long and tortuous ducts are essential a centrifugal fan must be used for mechanical extraction.

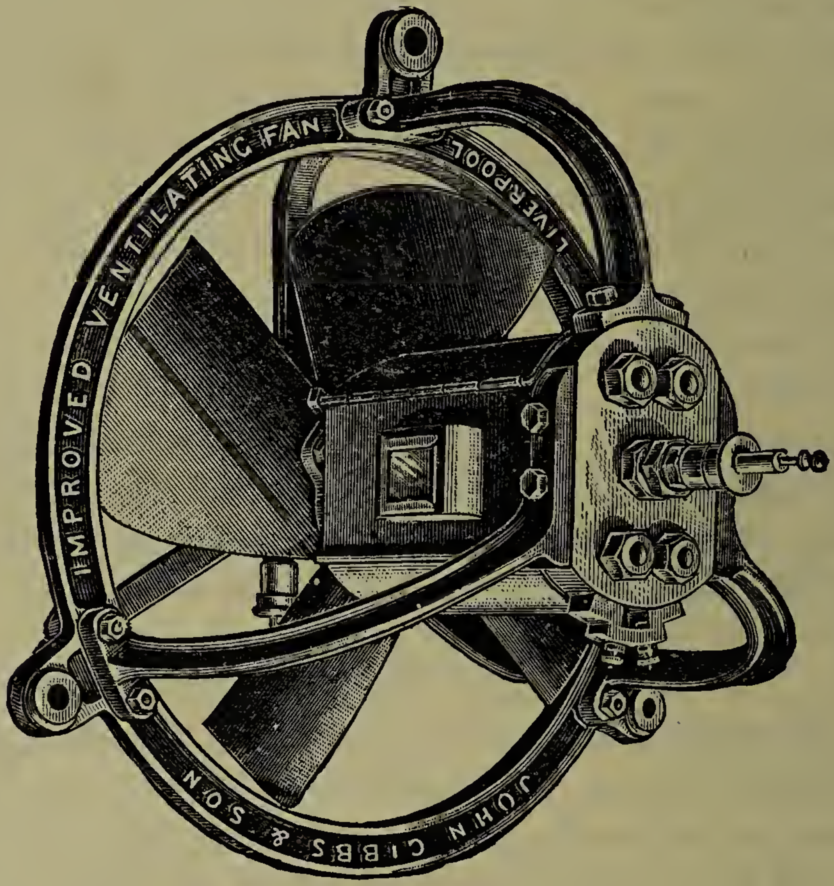

Fig. 14.—Ventilating Fan.

In factories the muscular work carried on and often the nature of the processes, creates an exceptional need for change of the air. In modern factories the very large size of the rooms adds to the difficulty. Ventilation by extraction is often arranged.

Experience in aeroplane factories of the removal of poisonous fumes of tetra-chlorethane, the solvent for the cellulose compounds used as a coating for canvas, has shown that satisfactory ventilation is obtained when large exhaust fans are placed at the floor level in one wall while air passing over hot pipes is admitted through openings situated in the opposite wall at a height of 8 to 10 feet above the floor. The openings should be as widely distributed as possible to ensure that the incoming air reaches every part of the room; they should be fitted with hoppers on the inside to prevent any down draught. Provision must be made for free passage of air out of the room from the fan ; openings exposed to the wind must be carefully shielded. The provision of ample inlet openings prevents the air entering with a velocity exceeding 5 feet per second, the limit to prevent any unpleasant sensation of draught.

In parts of large rooms where air supplied by the plenum system stagnates, exhaust fans are sometimes employed or paddles fixed on revolving shafting are used to waft the still air into the general circulation. Localised exhaust fans are often required in manufacturing processes. The removal of dust is effected by an air current produced by a pressure fan so arranged as to prevent the dust particles escaping from the place where they are produced into the general atmosphere. For this purpose the openings in the ducts should terminate in hoods shaped so as to envelop, as far as practicable, the seat of origin of the dust. Dust settling chambers are provided for heavy metallic dust. Heated fumes produced during the melting of scrap lead and other poisonous materials can be removed by vertical ducts expanded into a bell-mouthed hood of suitable size and shape, surmounted by a wind cowl. To remove volatile vapours heavier than air the openings to the duct must be at the ground level and as near as practicable to the place where the vapour is given off. Large volumes of air must be drawn away by fans.

In certain work, *e.g.*, stonemason's work or the filling and emptying of silica brick kilns, exhaust ventilation cannot be employed to prevent dangerous dust escaping into the air. Recourse must be had to respirators. Most respirators cause breathlessness on exertion due to the deep breathing caused by the rebreathing of carbon dioxide in the expired air, situated in the space in front of the mouth and nose. The pattern designed on the scientific principles laid down by Sir H. Cunynghame is open to fewer objections than any.[1]

For plenum ventilation the centrifugal cased fan with its eight or preferably more blades must be used on account of the resistance to the passage of air caused by the long ducts, heating coils and filters. It is usual to warm the air drawn by mechanical ventilation into buildings. When a separate system of warming is provided by radiators the air for ventilation purposes is warmed only to a sufficient degree to prevent complaints of draughts by reason of convection currents, and to avoid undue cooling of the ventilated apartments.

In some buildings, however, such as factories, skating rinks, cinema studios, the large areas to be warmed and the advantages of preventing the obstruction which would be caused by radiators often result in the method of direct warming by hot air being adopted. In these cases the air is heated to a sufficiently high temperature

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[1] See Appendix F, Second Report (Cd. 1746), 1914, of Royal Commission on Metalliferous Mines and Quarries.

(maximum 130° F.) to provide the heat transmission losses through wall, glass, etc., in addition to that required for humidification and tempering of the air. The disadvantages are that air is deteriorated for the purposes of ventilation if warmed above a certain degree; also air when heated to this extent at times acquires a burnt flavour.

Much of the objection to plenum ventilation owes its origin to the failure to recognise the importance of the humidity of the air supplied. If the relative humidity falls below a certain degree of saturation (20 per cent.) complaints of dry and parched throat, etc., will be made; in efficient installations the air is passed through an air washer specially built for humidification, usually of the spray type, and is able to take up the amount of water required.

At the Salmon Pastures School, Sheffield, where the plenum system is in use, the whole of the fresh air for warming and ventilation is taken in at a point where there is the least possibility of contamination. To remove any soot or dust present, the air is drawn through filters built in a cylindrical form; the structure consists of an iron frame over which specially prepared cocoanut matting is stretched, enveloping the whole frame. The matting is kept wet by a spray of water; in addition, water is placed in the trough in which the air filter revolves. The water in the trough is changed when foul.

The air, after passing the filter, is drawn into the building by means of two fans worked by an electric motor. Each fan can pass in 1,800,000 cubic feet of air an hour. The air is forced through the air ducts placed in the basement of the school, and is distributed to the various rooms by branch ducts and flues so arranged that a constant volume (fifteen changes per hour) can be obtained.

The inlets are placed at the height of 8 feet from the floor and are much larger than the outlets, which are placed on the same side of the room.

The windows must be kept closed, so that the air should circulate through the room in the prescribed direction to the exit opening or openings communicating with special exit shafts. This it does the more readily as it is under a slight pressure as the result of being constantly driven into the rooms. The foul air passes into the space under the roof and escapes through a shaft into the open air at about the level of the roof.

The warming is effected entirely by warm air, which is heated by passing over rows of pipes (heating batteries) through which passes steam under low pressure (5–10 lbs.). A separate heating battery is provided for each classroom and the central hall. The temperature of the different rooms, etc., can be altered by causing air to enter the flues without passing over the heating batteries.

It would, however, seem advisable when installing systems of mechanical ventilation in schools to make arrangements for warming *other than by* warmed air.

A more modern installation is found at the London New County Hall. In the conditioning room the air passes through a humifier chamber. A minutely divided spray of water is discharged from a number of nozzles so that it mixes with and completely saturates the air. Then the air passes through eliminator plates which separate and remove the free water from the air; this water contains the particles of dust, soot and minute foreign bodies suspended in the air and carried down by the spray. The air is fully saturated for the temperature at which it is placed in the humifier. In this plant steam is mixed with the spray water: the amount admitted is automatically controlled by a thermostat acting in conjunction with a diaphragm steam valve. In hot weather cooling of the air supplied can be effected by the use of fresh cold water in the water tank.

Fresh air may have to be driven into the centre of capacious rooms in those cases where the width is too great to ensure sufficient air movement in all parts by means of exhaust fans and air inlets in the walls. Where there is exposure to great heat as before furnaces in rolling mills or in the manufacture of glass, cool air may be needed locally as a douche for workers; it is supplied through channels or ducts which open in the desired positions. Definite exits should be low down in the walls so arranged that the incoming air sweeps through the room before reaching them.

The degree of purity of the air in crowded rooms, or in work rooms in which impurity is caused by the carrying on of special trade processes, can, by means of artificial ventilation, be maintained in a way which would be quite unattainable under ordinary conditions. In rooms in which dusty occupations are carried on, and in places in which offensive effluvia are necessarily evolved, artificial ventilation has proved invaluable. Researches, conducted by Carnelley, Haldane, and Anderson, concerning the ventilation of schools in Dundee, showed how advantageously mechanically-ventilated schools compare with those in which natural ventilation is alone relied upon. In the Dundee schools, the air was propelled over hot pipes, and entered the schoolrooms about 5 feet above the floor, the outgoing air escaping through apertures some 2 feet above the floor into a chamber in the roof, and passing thence through louvred exits into the outer air. The air of the schoolrooms thus ventilated was found somewhat purer, on an average, than the air of naturally ventilated schools, both as regards CO_2 (1·23 as against 1·86 per 1,000 volumes), and, as regards organic matter (10·1 as against 16·2 volumes of oxygen required per 1,000,000 volumes of air). The most striking difference under the two sets of conditions was, however, that observed in the number of micro-organisms, which amounted to 152 per litre in the naturally ventilated, and to only 16·6 per litre in the mechanically ventilated schools.

The vast majority of schools are ventilated by natural means; the cost of the machinery and its installation and maintenance and the care required in the upkeep of mechanical systems militate against their adoption.

The Theatres Committee of the London County Council are of opinion that the only efficient means of securing satisfactory atmospheric conditions in a place of public entertainment is the installation of an adequate system of mechanical ventilation, combined with a system of heating under which fresh air is warmed before entering the building. In new and reconstructed premises they have already required such an installation to be provided.

EXAMINATION OF SUFFICIENCY OF VENTILATION

In order to secure adequate ventilation, various legal requirements as to cubic (and superficial) space to be allotted to each person are contained in different Acts. The larger the cubic space the more easy is it to supply the air without causing a draught.

The cubic space and area allotted for the school-child has been adversely criticised. C. E. Paget, in his "Handbook on Healthy Schools," suggested 400 cubic feet per child as a minimum for elementary schools, and 800 cubic feet for public schools. Between 400 cubic feet and the 80 cubic feet of the Code there is a vast difference from the point of view of seating accommodation, and while it is clear that 80 cubic feet are quite inadequate, it is unlikely that, at any rate under existing circumstances, 400 cubic feet can be generally provided.

The inquiries of Carnelley, Haldane, and Anderson, already referred to, led these observers to the conclusion that the best results were obtained in schools having a system of mechanical ventilation by propulsion, and in instances quoted by them between 800 and 1,400 cubic feet per head were supplied hourly. W. N. Shaw, in a report upon the ventilation of class-rooms in Poor Law schools, suggests that a minimum supply of 1,500 cubic feet per head per hour should be required. He arrives at this figure as the limit by allowing, in the first place, for the fact that the schoolrooms can be aired after an hour's use, and hence a supply at the rate of 2,000 cubic feet per hour would be sufficient to keep the impurity within De Chaumont's limits, assuming each person to contribute ·6 cubic foot of carbon dioxide per hour; again, he also takes into account the fact that he is dealing with children and not with adults.

17–21 sq. ft. is available in some public elementary schools in U.S.A.

In the examination of dwelling-houses as to their fitness for human habitation the essential points to observe are the existence of through ventilation and the presence of a fireplace or an outlet in each room. The need for further ventilation in a room is shown by the room smelling stuffy to a person who has just entered from the outer air. It should be remarked that stuffiness connotes a temperature of the air raised above that of the external air, excessive moisture and stagnation of the air.

The anemometer is much used in factories. The space traversed by the sails is automatically measured, and the corresponding rate of movement of the air indicated on the dial. Having ascertained which are the outlets by the use of smouldering brown paper, their area is measured, and from the rate of movement, as shown by the anemometer, the amount of air entering in the room can be calculated.

Probably the most exact method that can be utilised at present to ascertain the sufficiency of ventilation is to determine by chemical analysis the amount of carbon dioxide present in the air of the room; used air in rooms containing more than 10 parts of carbon dioxide per 10,000 cannot be breathed without danger to health. These observations may well be supplemented by the use of the kata thermometer.

	Minimum space per head in cu. ft.	Act, etc.
Army barracks	600	British Army Regulations.
Army hospital wards . . .	1,200	,, ,, ,,
Bakehouses above ground where night work is carried on by artificial light other than electric light.	400 (9 p.m. to 6 a.m.)	Order under Factory Act, 1901.
Bakehouses underground . .	500	,, ,, ,,
Canal boats (persons over 12 years).	60	Local Government Board Regulations. Canal Boats Act, 1877.
,, ,, (persons under 12 years).	40	,, ,, ,, *Note.*—An after cabin must not be less than 180 cu. ft. in capacity and a fore cabin not less than 80.
Houses let in lodgings. Room used wholly or partly as sleeping apartment.	400 [1]	Bye-laws—Houses divided into separate tenements, &c. London County Council.
Temporary exemptions (see footnotes)		
Room used exclusively as sleeping apartment.	300 [2] (150 if under 10 years of age)	,, ,, ,,
Room not used exclusively as sleeping apartment.	200[2] (if under 10 years of age)	,, ,, ,,
Common lodging houses (sleeping rooms).	300	Local Government Board Model Bye-laws.
Public elementary Schools .	80	Board of Education. *Note.*—Minimum floor space in old schools 8 sq. ft., in new schools 10 sq. ft., for children under 7 years 9 sq. ft.; for combined class and playrooms for younger children, 12 sq. ft.
London County Council Schools	130	London County Council. *Note.*—Minimum floor space, 10 sq. ft.
Seamen's cabins	120	Merchant Shipping Act, 1906.
Workrooms, non-textile . . .	250	Factory Act, 1901.
,, non-textile during overtime.	400	,, ,,
Cows in cowsheds	800	Local Government Board Model Regulations under the Dairies, Cowsheds, and Milkshops Order.

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[1] Comes into force six months after expiry of Rent and Mortgage Restrictions Acts, 1920 and 1923.

[2] Goes out of force at corresponding time.

The area and cubic space of rooms of various shapes can be calculated, after measurement of the height, length, and breadth, by the application of certain mathematical rules. Given the number of persons occupying the room, the amount of cubic air space and floor space for each can be ascertained.

Area of circle = square of diameter × 0·7854.

Circumference of circle = diameter × 3·1416.

Area of ellipse = the product of the two diameters × 0·7854.

Circumference of ellipse = half of the sum of the two diameters × 3·1416.

Area of square = square of one of the sides.

Area of rectangle = the product of two adjacent sides.

Area of triangle = base × $\frac{1}{2}$ height.

Area of a parallelogram = divide into two triangles by a diagonal and take the sum of the areas of the two triangles.

Area of trapezoid = half the sum of the parallel sides × the perpendicular distance between them.

Cubic capacity of cube or solid rectangle = length × height × breadth.

Cubic capacity of solid triangle = area of triangle × $\frac{1}{3}$ height.

Cubic capacity of cone or pyramid = area of base (circle) × $\frac{1}{3}$ height.

Cubic capacity of dome = area of base (circle) × $\frac{2}{3}$ height.

Cubic capacity of sphere = diameter^3 × 0·5236.

To determine the available cubic space, *i.e.*, the gross cubic space minus the space occupied by solid objects in the room, bulky furniture must be measured, and the space subtracted, also 3 cubic feet is usually deducted as the space occupied by each individual, and 10 cubic feet for each bed and occupant.

FOR WARMING OF ROOMS AND BUILDINGS

The physical processes concerned in warming are radiation, convection and conduction. "The difference between a space heated by radiation and convection respectively is brought out by comparing the exhilarating conditions of a sunny winter day in the Swiss Alps where, although the air may be below freezing point, the radiation from the sun keeps one comfortably warm with the relatively stuffy and depressing conditions of a hotel which is warmed by a hot air supply; in the former case the air is very cold and the body is kept warm by radiation; in the latter the air is warm and there is no radiant heat."[1]

In this country the warming of rooms is mainly effected by open fireplaces; they possess the great advantage of providing an excellent means of ventilation, but they do not secure anything like uniformity of heating effect in different parts of the room, and they are open to the objection that much of the heat generated escapes up the chimney, and does not warm the room at all. The older forms of fireplace were particularly wasteful; in modern grates attention is usually given to certain points with a view to limiting, as far as possible, the loss of heat. Thus, in the old form of grate, iron was largely used. It is now recognised that radiation must be mainly relied upon for heating a room. The heat of iron surfaces imparts warmth by conduction to the adjacent air, which, in turn, by convection, conveys heat to distant parts of the room, but, in practice, most of the heat communicated to the iron of a grate escapes up the chimney. Hence, in modern grates, iron is, as far as possible, discarded, and firebrick is used in its place, with the object of insulating the heat produced. The shape of the stove is, moreover, important from the point of view of increasing radiation; the back of the stove should lean forwards over the fire, the bottom of the grate being made deep from before backwards, and the "throat" of the chimney should be contracted. The slits in the grating beneath the fire, and the bars in front of it, should be made narrow, and, with the object of promoting slow combustion, air may be excluded from beneath the fire by the use of what Pridgin Teale called an "economiser," a close-fitting shield placed in front of the space into which the ashes fall.

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[1] Simon and Fitzgerald, "The Smokeless City," p. 30.

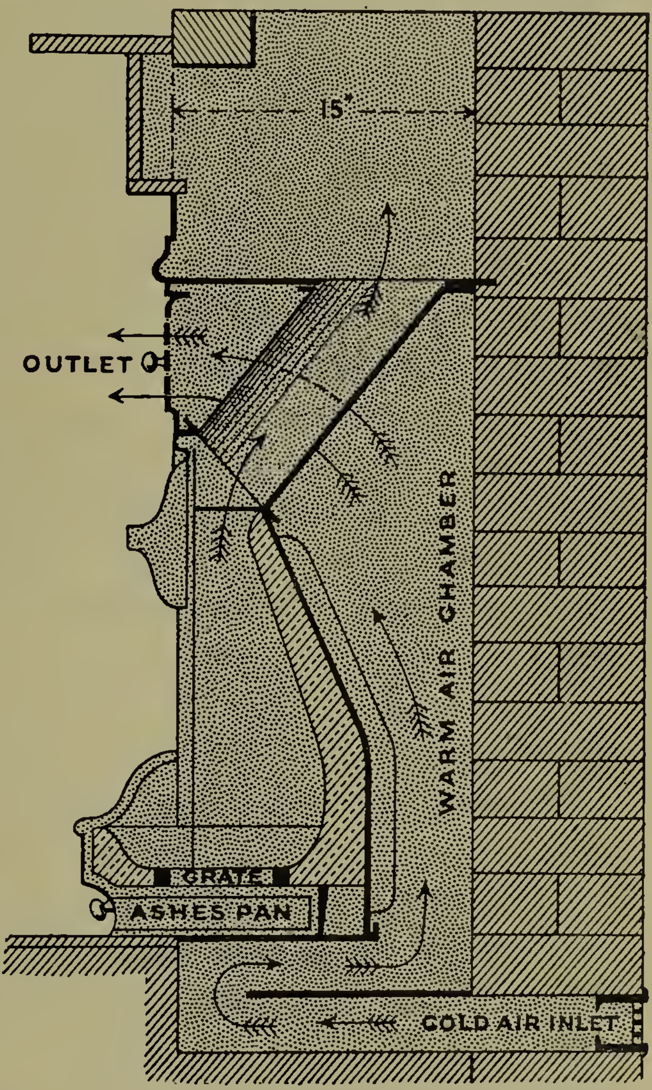

Fig. 15.

Section of "Draw-Well" Ventilating Firegrate.

The amount of heat imparted to the room depends upon the amount of draught; with one change of air of the room per hour the heat lost was 16 per cent., with ten changes per hour 50 per cent. If the chimney flues are placed on inner walls of houses much of the heat warms the upper rooms; when placed on outer walls as much as 25 per cent. of the fuel value of the coal may be lost to the open air. The radiant heat from coal burnt in an open fire is about 25 per cent. of the fuel value of the coal, another 5 per cent. is conveyed to the room by convection. Coke (which should be kept dry) is a more profitable fuel [1] than coal for warming rooms; comparative figures for the radiation from coal and coke fires from the same grate were: coke, 1·97; coal, 1·63; wet coke, 1·29.

Open fireplaces can be utilised to warm incoming air. An air-grid communicates with a chamber surrounding the back and sides of the fireplace and extending up around the lower part of the chimney flue. The warm air escapes into the room through an opening placed above the fireplace. The Manchester stove much used in hospital wards and schools is constructed on the same principle.

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[1] Also it is the burning of the volatile hydrocarbons in bituminous coal that produces black smoke; coke fires are in consequence smokeless.

Closed stoves are much less wasteful of heat than fires, as the sides of the stove, and part of the flue, communicate heat by conduction and convection to the air of the room. In what are known as "cockle stoves" the apparatus is enveloped in a chamber, the air of which becomes heated and can be distributed to various parts of a house. This principle is in common use on the Continent; the heated air should be fresh air, and not merely that obtained from the chamber in which the stove is situated. The closed stove does not secure ventilation so satisfactorily as does an open fire; moreover, closed stoves sometimes render the air of rooms unpleasantly dry, and there is risk, under certain conditions, of pollution of the atmosphere with carbon monoxide. If the stove is overheated, particles floated in the air become charred and cause an unpleasant smell.

Cast-iron stoves should only be used when they fulfil certain requirements. They should be lined with fireclay to prevent overheating; the heat can be made less intense by using stoves of a large size or by increasing the amount of metal to be heated by the addition of flanges. In new buildings the Board of Education does not allow the common stove with a pipe through the wall or roof to be provided.

Any stove, before it can be approved, must be—

(i) provided with a proper chimney like that of the ordinary open fire.

(ii) of such a pattern that it cannot become red-hot or otherwise contaminate the air.

(iii) supplied with fresh air direct from the outside by a flue not less than 72 square inches in area.

(iv) of such a size or shape as not to interfere with the floor space.

Warming is combined with ventilation when pipes conveying fresh air from the outside of the building are made to pass through stoves and out into the room.

Gas Fires, although more expensive than coal fires, have the advantages of being convenient and very cleanly, and entailing practically no labour; no soot, dust, or ash is formed, and the laying of the fire is avoided. When heat is required quickly and for a short time only, gas fires are more economical than coal fires, the expense of the materials required to start the fire being avoided.[1] They do

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[1] Reports of the Fuel Research Board for 1918 and 1919 give the cost of producing 100,000 British thermal units from—

Good coal at 54*s.* per ton	2*d.*
Gas at 4*s.* 2*d.* per 1,000 cu. ft.	10*d.*
Paraffin at 2*s.* 6*d.* per gallon	19*d.*
Petrol at 3*s.* per gallon	25*d.*
Electricity at 2*d.* per unit	58*d.*

not, as a rule, act so efficiently in promoting ventilation as open fires, and their use may be associated with escape of carbon monoxide into the air of the room if the fittings are defective.

The proportion of available heat radiated is about 45 per cent.; in various experiments the convected heat has been found to vary from under 10 to 21 per cent.

Every gas stove used for heating rooms should be provided with a flue; the use of flueless gas stoves "can only be justified in such places as entrance halls, passages, landings, etc., where ventilation is free and where occupants do not remain for any considerable length of time."[1]

As the up draught of a gas fire when first lighted is small the diameter of the flue should be at least 4 inches. The flue should slope gradually towards the chimney flue and be free from abrupt bends; the "elbow" so often seen is especially objectionable.

To aid ventilation, in addition to the front of the ordinary gas fire another opening at least 20 square inches in diameter should be provided; its size should be capable of regulation.

When atmospheric (Bunsen's) burners are used lighting back occurs when the gas is turned too low or exposed to a sudden draught. This lighting back is a serious matter, as it causes an objectionable smell of half-burnt gas and soon causes headaches. Various devices have been used to endeavour to prevent it, the most successful being the use of fine wire gauze to cover the mouths of the Bunsen burners.

Gas stoves can be so constructed as to assist in ventilating the air of a room. Of these Bond's Euthermic stove is an example.

This stove is fixed against an outer wall and consists of an inner vertical cylinder, open above and connected by an air duct passing through the wall into the outer air. It is surrounded by an outer casing. A ring of gas jets is placed beneath the cylinder and heats the fresh air entering from outside. The products of combustion between the casing and the inner cylinder carry with them the air of the room and are conducted to the flue.

Anthracite stoves are a very efficient (and smokeless) form of heating; they however have very little ventilating effect. The cost of anthracite is less than that of an equivalent amount of ordinary coal. *Paraffin* is used in oil stoves to warm rooms; no ill-effects

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The British Thermal Unit is "the quantity of heat required to raise one pound of water through one degree Fahrenheit" (strictly speaking from 32° to 33° F.); it will also raise 53 cubic feet of air through the same limits of temperature; 3·97 British thermal units = 1 calorie.

[1] See Report of Joint Committee on flueless gas heaters, "Journal of the Royal Sanitary Institute," April, 1924.

have been observed in spite of the absence of a flue to carry off the products of combustion.

Warming by Means of Hot Water or Steam—Warming in the newer schools is carried out by means of hot water contained in a boiler and system of cast-iron pipes passing from and returning to the boiler.

Use is made in this method of warming of the principle of convection. The water heated in the boiler rises in the pipes and parts with its heat to the air of the building; becoming cooler, it increases in weight and gradually falls in the return pipe to the boiler.

Warmth is conveyed to the room by means of radiation from the hot pipes, also by convection, the air in contact with the pipes being warmed and gradually distributed throughout the room.

When this form of heating is used it is with advantage supplemented by open fireplaces, the flues of which are always useful for ventilation.

The advantage of this method of heating is that the corridors and lobbies can be warmed.

In the *low-pressure gravity system* from the top of the boiler passes a cast-iron pipe 4 inches in diameter. This gives off to each room branches of the same diameter, each of which, after passing round the room, is bent back on itself, joining the main return pipe which enters the boiler at the bottom.

A valve is provided for the pipes of each room in order to control the warming of the room.

At the highest point of the system an escape for air and steam is provided. Any loss of water is supplied by a small cistern connected with the return pipe. The average temperature of the water in the pipes varies from 160°–180° F. Twelve feet of the 4-inch pipe are required for each 1,000 cubic feet of air in the room in order to maintain a temperature of 65° F. In the Staffordshire type of school 25 square feet mean heating surface low pressure (per 1,000 cubic feet) are provided.

When radiators—vertical pipes of ornamental design—are used for warming, the diameter of the circulating pipes is smaller—(about an inch or less). The amount of flow of water through the radiator and in consequence the amount of heat given off can be regulated. If dependence is placed on the force of gravity alone it is difficult to maintain a regular, even flow of water through all parts of the system; steam has been successfully used to assist the flow. Heated water is forced by steam pressure into the main pipe leading to the radiators and returns to a chamber full of steam used to heat the water in the first place. In this chamber the steam parting with its heat condenses and the fall of pressure sucks the water along the return pipe. The temperature usually employed is no greater than in the gravity system without the assisted circulation. This modification allows of the use of the " panel " system of warming. Pipes of small diameter—less than 1 inch—are laid in a composition, a mixture of compressed sawdust, cement, and asbestos, and placed as panels either in the wall near the floor level or actually in the floor of the room ; cold currents near the floor level are avoided and the feet of the occupants of the room kept warm. See Fig. 16.

Hot water under pressure, at temperatures considerably higher than 212° F., is employed in Perkin's system. A complete circuit of wrought-iron pipes, usually about $\frac{7}{8}$ inch internal and $1\frac{5}{16}$ inch external diameter, is constructed, and part of the circuit is exposed to the heat of a furnace. Expansion tubes, of comparatively large diameter and partly filled with air, are placed at the top of the system, and these allow for the expansion of the water, but the air does not extend into the smaller pipes so as to interfere with the water circulation. Water requires to be added from time to time through the tubes at the upper part of the system, to replace waste. In the event of a stoppage occurring, the weakest part of the system is that in the fire, and if a pipe bursts there no serious damage is likely to result.

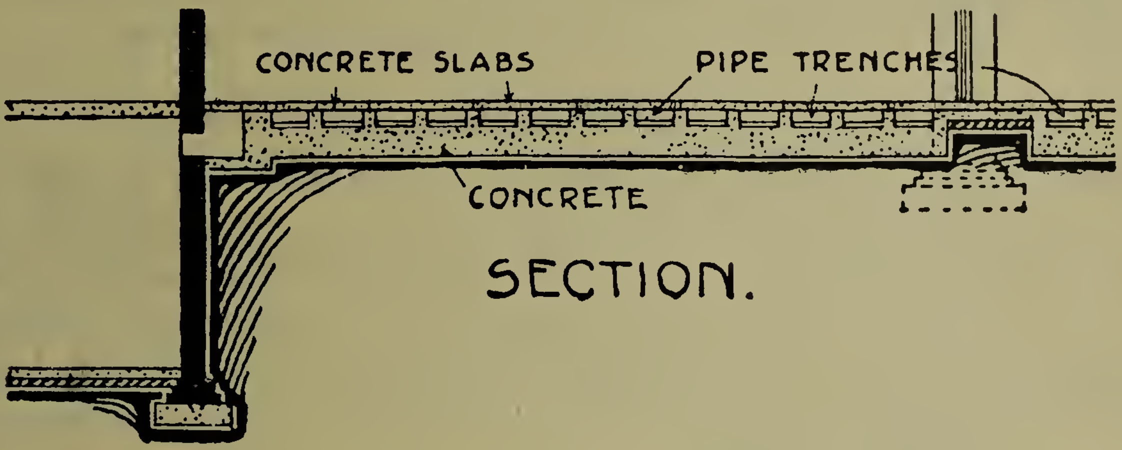

FIG. 16.—Section of floor showing arrangements for warming floor. N. Wingfield Council School, Derbyshire.

The water can be heated to a temperature of 300° F. Eight feet of such pipe are equivalent to 12 feet of pipe in the low-pressure system.

When *steam* is used, it is conducted from the boiler in tubes of $1\frac{1}{2}$ inch in diameter, covered with felt to avoid condensation, to the place which requires warming. The tube is expanded to at least four times its width ; the steam is allowed to condense, and in doing so gives out heat to the surrounding air. The condensed water is conducted back to the boiler by a special set of pipes.

In contrasting the advantages and disadvantages of these several methods of warming rooms, it must be borne in mind that where heat is imparted by radiation, the air remains comparatively cool, whereas when heat is transmitted by convection the air itself becomes hot, and is thus rendered dry. In addition to being more cheerful, and keeping the air fresher, the open fire system involves less initial outlay than hot pipe systems; but, on the other hand, the annual cost of open fires is greater than in the case of stoves, steam pipes, or large hot water pipes, the heat is unequally distributed, and the air becomes more highly charged with micro-organisms. Stoves are particularly economical, but liable to smoke and get out of repair. With respect to the relative merits of small high pressure and large low pressure pipes, the former are cheaper, less obtrusive, more speedily set in action, and give better results as regards the condition of the air.

Warming by steam is very convenient for use in factories, etc., where steam must be generated for other purposes; the steam is able to travel through the circuit with ease no matter how large or irregular the buildings may be and in consequence a very uniform temperature can be obtained throughout. Its use, however, for schools is unsatisfactory—the heat produced is too intense and too concentrated in one place, and air laden with dust particles on coming in contact with the pipes is given an objectionable odour.

LIGHTING

Natural lighting is to be preferred to artificial. It would seem to be established that the ultra-violet rays present in sunlight have strong germicidal action; rooms into which sunlight does not readily enter are deprived of this natural process of disinfection. Sunshine and sunlight play a part in promoting good spirits and cheerfulness. Daylight stimulates a healthy skin reaction and promotes the metabolism of the human body.

Young children especially react to their surroundings; lack of suitable stimuli rapidly produces ill effects. Absence of sunshine and light soon causes anæmia and debility; children become predisposed to infections, especially that of tuberculosis. So well is this recognised in Holland that the legislature forbids the employment of women and children in workrooms to which daylight cannot obtain access.

Considered as an illuminating agent the superiority of daylight is largely due to the amount of illumination, which in favourable conditions is far in excess of that provided by any form of artificial light. Bright unrestricted daylight in the open gives several thousand foot-candles. An illumination of several hundred foot-candles on a well placed desk is quite usual. Although the adaptability of the eye enables it to work conveniently at an illumination far less than this yet the human eye, being developed to use daylight, functions best in daylight. An even more important factor is the evenness with which daylight is diffused over large surfaces; although the intensity is so great there is no glare from the real source of light, the sun. The illumination received in a room usually comes largely from the sky, much is also derived from reflection from surrounding buildings. The light coming from such a large area gives soft shadows and penetrates into every part of the room with a completeness rarely attained by artificial light.

Insufficiently lighted houses tend to become dirty and favour the breeding of body vermin. The absence of adequate light in a house prevents persons doing their work and causes an economic loss; it has a marked tendency to produce eye strain. The pupil dilates in dim light; during accommodation for near vision the pupil is constricted, the effect being to diaphragm the lens and so to secure improved definition and more exact vision such as is required for close work. Deficient light for near work leads to a constant struggle, an important factor in producing eye strain.

In practice the natural lighting of the rooms depends upon the area of the windows. In ordinary rooms the usual rule is that the area of the windows, exclusive of the framework, should be one-tenth of the floor space. In the lighting of schoolrooms a higher degree of illumination is required. The investigations of Laporte and Broca show that for reading average type an illumination of not less than 3 to 4 foot-candles is necessary; for the perception of light and shade much the same degree of illumination must be available.

The total area of windows, exclusive of framework, should be one-quarter to one-sixth of the floor space of the room.

The glass should be plain and transparent; no form of glazing should be permitted that diminishes the amount of light.

The strongest light should come from windows on one side of the room in order that the desks may be so arranged that the light comes from the left hand of the children. In this way no shadow of the hand in writing or drawing is thrown on the paper.

Where left light is impossible, right light is next best. The light should not come from the front of the children lest their eyes should be dazzled. Light coming from behind them throws a shadow on the paper, and is in the face of the teacher, who can less easily observe the children.

The arrangement of the desks should be such that the light available is evenly distributed throughout the class-room. Desks should be arranged parallel with each other at right angles to the window, and where possible in the space intermediate between two windows.

The windows should not be confined to one side of the room, but properly distributed over the walls of the class-room, so that every desk is sufficiently lighted. From each seat the children should be able to see the sky.

The windows should be made sufficiently low; no windowsill should be more than 4 feet high. The glass line of the window furthest from the teacher should be on a line with the back of the last row of desks.

In the lighting of workrooms special consideration has been given to the "daylight factor," the relation the light reaching any place inside a building bears to the amount of light outside at any moment. At the centre of some workrooms depending entirely on lateral windows the factor falls as low as 0·01 per cent. For the general lighting of a workroom the illumination should be one foot-candle; if no fine processes are carried on, artificial light may not be necessary until the illumination falls below 0·5 foot-candle. In most factories the daylight factor is at least 0·2 per cent.; to obtain one foot-candle illumination with this daylight factor the amount of daylight must be not less than 500 foot-candles.

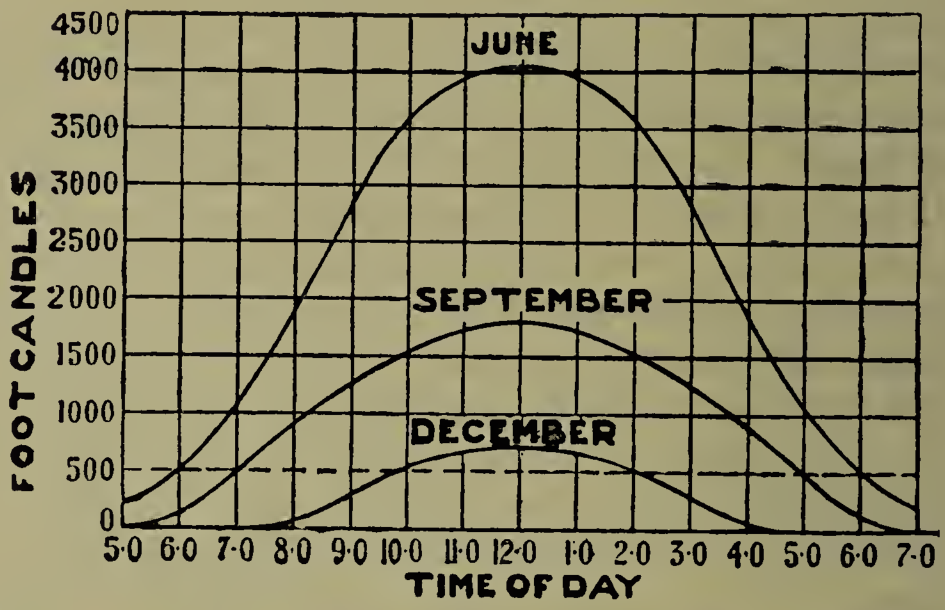

FIG. 17.—Curves showing approximate variation of daylight from 5 a.m. to 7 p.m. on average days in June, September and December.

During four months of the year unless the daylight factor exceeds 0·2 per cent. this amount of natural illumination is not available at the commencement and end of work. If the daylight factor be increased to 2 per cent., a very reasonable standard, an illumination of at least 0·5 foot-candle may be obtained with natural light during working hours, 8 a.m. to 5 p.m. throughout the year except for the last hour, 4 to 5 p.m. during a few weeks in December. Much can be done to admit more daylight into the average factory, the size of the window can be increased; the height of the window is, however, of more importance than its width, not only because of the greater sky area subtended but also because of the angle of incidence of the light, which is of course dependent on the height of the obstructing building. Obstruction to light within is often due to the storing of packing cases, etc., in front of windows. The windows are often grimy; their regular cleansing is facilitated by making all window casements pivot inwards. By keeping ceilings white by frequent limewashing, much of the light entering is reflected on the work below; the walls of workplaces should be maintained a light colour, the lower part being somewhat darker in tone (factory green or some other medium colour) to render the lighting restful for the eye.

Artificial Lighting—The light given out when *coal gas* is burnt is derived from white-hot particles of carbon formed by the splitting up of the illuminants. The ordinary flat-flame burner only gives 2 to 3 candle power per cubic foot of gas. Various improvements have been made.

> "Ordinary flat-flame burners required about seven-tenths of an inch of water pressure. When this value was greatly exceeded they tended to roar and smoke; consequently it became usual to include in the burner a governing device, such as a small cone which rose and checked the admission of gas should the pressure rise above the desirable point. With the introduction of incandescent mantles it was found necessary to raise the general standard of pressure somewhat and this also led to the introduction of 'economisers,' small caps which were fitted on to the existing flat-flame burners, and adapted them to the changed conditions, enabling better conditions of combustion to be secured with a more luminous flame." (L. Gaster.)

The Argand round burner yielded a slightly higher efficiency but the long flame was unsteady and readily affected by draughts.

Enrichment of the gas is brought about by the "albo-carbon burner" in which the gas is caused to circulate over naphthalene which becomes volatilised and enriches the flame, giving as much as 5 to 6 candle power per cubic foot per hour.

But the Welsbach burner in which the combustion of a mixture of coal gas and air renders a mantle incandescent has replaced them all and has largely contributed to turning attention away from gas itself as an illumining agent to gas as a heating agent to bring a web of suitable material to incandescence. A woven cylinder usually made of ramie fibre is soaked in solution of thorium nitrate with a small proportion of cerium nitrate.

Inverted gas mantles possess marked advantages as regards distribution of light (a far larger proportion of the light being thrown downwards) and durability; the smallest types are stated to consume less than one cubic foot of gas per hour and to yield up to 20 candle power.

The efficiency of gas as an illuminant has also been increased by the use of gas under pressure: an efficiency of 60 candle power per cubic foot of gas can be obtained by this means and sources of light of several thousand candle power are available.

The earliest form of *electric lighting* was the arc lamp in which the illumination is produced by the passage of a current between two carbon rods in close apposition. The resistance of the air break is sufficient to produce enough heat to make the carbon points brilliantly incandescent. In the flame arc lamp the light is derived mainly from a highly luminous vapour; the chemical treatment of the carbons has now trebled the efficiency of the older lamps and made light of several thousand candle power available. These lamps are suitable for outside lighting and the illumination of large halls; for domestic lighting the ordinary glow lamp with its carbon incandescent filament or a later modification is used. Metallic filament lamps yield more than three times the light of carbon filament lamps for the same consumption of energy. A filament of tungsten is most widely used at present: this operates in a vacuum.

One of the latest developments of the filament lamp is the gas-filled or "half-watt" lamp. The tungsten filament is brought to incandescence in an atmosphere of nitrogen or oxygen which improves its rate of volatilisation, enabling the lamp to be run at a considerably higher temperature, thus securing higher efficiency; in some cases only 0·6 watt is consumed per candle. This lamp is used in the system of *indirect lighting* by means of lamps suspended in inverted opaque bowls or hoods which serve to distribute the light evenly over the white ceiling, screening the source from the eye and avoiding direct glare. When a translucent material is used instead of the opaque bowl while most of the light is still directed on the ceiling a certain proportion is transmitted through the bowl; this method —the *semi-indirect*—combines the advantages of the direct and entirely indirect systems. Gas is seldom used for indirect lighting; its use for semi-indirect lighting is more extensive.

One of the furthest developments of the glow lamp, the quartz tube mercury lamp, is of importance on account of its furnishing a ready source of ultra-violet rays. Mercury lamps are long exhausted tubes with an electrode at each end; they contain a small quantity of mercury, and when the lamp is alight the entire tube is filled with luminous mercury vapour. By using quartz glass in their manufacture a higher temperature can be reached; the luminous efficiency is increased and a spectrum more closely resembling that of white light is produced; above all quartz glass allows of the passage of ultra-violet rays.

Lighting by use of Petroleum Oils (*Kerosene*)—Oil for burning in lamps is obtained by the distillation of crude petroleum oil. When heated to a certain temperature (the flashing point) kerosene gives off an inflammable vapour. In order to avoid explosions no oil should be used the flashing-point of which is below 100° F.

Lamps should be strongly made; the reservoir and burner should be especially strong; the base of the lamp should be strong and heavy. The wick should fit the wick tube exactly; the surface of the lamp should be clean and free from oil; neglect of this precaution causes a smell and may give rise to accidents. In extinguishing a lamp without a special extinguishing apparatus, the wick should be turned down until there is only a small flickering flame; if a piece of flat metal is then placed on the top of the chimney the flame goes out.

Lamp explosions are caused by the flame of the lamp passing down into the vapour over the oil in the reservoir; hence the necessity of a well-fitting wick and the danger of blowing down a lamp chimney to put it out. A leakage of oil through a defective reservoir coming in contact with a light will also cause an explosion.

Accidents often occur owing to the lamp being unsteady and having a breakable reservoir. Lamps should always be seen to during the daylight.

The burner may be kept clean by occasionally boiling it in water containing washing soda. A new wick should be thoroughly dried at a fire and soaked in oil before putting it into the lamp.

When the lamp is first lit the wick should only be turned up a little, so as to allow gradual expansion of the glass of the chimney and avoid breaking it; afterwards it should be turned as high as possible without causing a smoke, otherwise an unpleasant smell is caused. Quite as much oil is used with a low flame as a high one.

The modern petroleum lamp can give 100 candle power due, in a large measure, to the round wick which enables air to have more perfect access to the flame. By vaporising petroleum and mixing it with air in the correct proportions it can be used to heat an incandescent mantle. The Kitson light used for street lighting and the incandescent oil lamps used in isolated lighthouses are examples of its successful use.

Petrol air gas consists of air to which has been added a small percentage of petrol vapour (1½ to 6 per cent.). It is claimed that the higher proportion is safer in that it is farther removed from the explosive range. Incandescent burners with inverted mantles can be used for the combustion of petrol-air gas.

Acetylene has been made practicable as an illuminant by the manufacture of calcium carbide from a mixture of lime and carbon in the electric furnace. Acetylene is generated immediately water is brought into contact with calcium carbide. Careful purification has enabled acetylene to be burnt with safety and without smell. It is doubtful whether there is any advantage in using incandescent burners with this gas for ordinary illuminating purposes.

Illumination by *candles* is almost a thing of the past. Not only is the illuminant poor but the relative cost is far greater than in the case of the other common illuminants, and the low melting point of the fats causes volatile products to be given off before they reach the flame with the result that much unconsumed carbon is added to the air.

The success of artificial lighting depends chiefly on adequate candle-power, the correct position of lights, and effective shading.

Simple rules of good lighting have been issued by the Illuminating Engineering Society. Not only is it necessary to obtain as equal a distribution of the light as possible but glare must be avoided. The intrinsic brilliancy of light is often such that it is unendurable to the gaze; the bedazzlement of eyes by lights which are highly concentrated in brilliant points of light reduces the power of the eye to see clearly other objects in the same field of view: brightness alone without concentration produced by reflection of light from very smooth paper or other polished surfaces causes discomfort in vision; these phenomena are summed up in the generic name glare.

Semi-opaque globes or shades are used to diffuse light, in other words to make it appear as if it emanated from a larger object, making the retinal image larger and less concentrated. Modern dioptic globes are, however, preferable; while enlarging the visible outline of the source, they waste the minimal amount by absorption.

R. KING BROWN

CHAPTER II

WATER

I.—SOURCES OF WATER SUPPLY AND METHODS OF PURIFICATION OF WATER

REFERENCE has been made in the previous chapter to some of the elementary properties of water and of the aqueous vapour given off by it. The fact that the density of water is greatest at 4° C. has been mentioned as showing why ice collects and floats on the surface. Water in the act of freezing expands, hence the liability of water pipes to be fractured in times of frost; the fact that such fracture has been caused is, of course, not made manifest until the thaw occurs. This expansion of water on freezing exercises important influence in connection with the weathering of rocks and the disintegration of soil. Water is a very bad conductor of, and has a high capacity for, heat; it is taken as the standard with which the specific heats of other substances are compared. The influence of pressure upon the boiling-point of water has been referred to, but it should be mentioned that the boiling-point is raised when certain substances are contained in solution in the water.

The colour in water is due to matter in solution, turbidity to suspended matter. While colour renders water less attractive, less desirable and in consequence less valuable for public supply, turbidity has a hygienic significance.

Rain-water—The source from which all water is originally derived is rain. The rainfall in a locality may be of importance in many ways as regards health conditions. Now that it is becoming more and more commonly the practice to bring water from considerable distances, for the supply of thickly populated districts, the rainfall over a given " catchment area " becomes a matter of the first consequence in connection with the determination of the sufficiency of such an area for the supply of a community. The amount of rain falling upon the area will have to be considered, and also the extent to which it may be expected to percolate through the ground, in order that an estimate may be made of the quantity of water likely to accumulate in natural underground reservoirs, formed by the holding up of the water contained in pervious formations by underlying impervious strata.

The instrument employed for estimating the amount of rainfall is the "rain-gauge." The pattern used is generally 5 inches in diameter, and the rain collected passes through a funnel into a bottle, this arrangement being designed to check evaporation. From the bottle the water is from time to time removed to a measuring glass, and the quantity of rain collected per unit of surface is stated in inches, or fractions of an inch. The rainfall varies greatly in different parts of the world. The average yearly rainfall over the whole of England is upwards of 30 inches, but in the eastern counties it is less than 25 inches, while in the hilly districts adjoining the western coast the amount is much greater, and in particular localities it may considerably exceed 100 inches per annum.

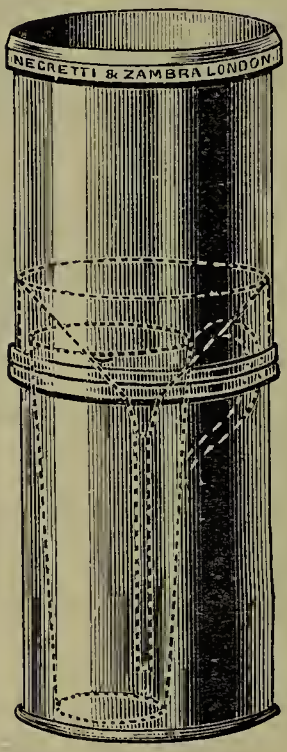

Fig. 18.—Rain Gauge.

"One of the difficulties which has been felt in the past by rainfall observers has been the accurate measurement of small quantities of rain of the order of a hundredth of an inch or less. In the ordinary pattern measuring glass with flat base it is very difficult to determine the lowest graduations with accuracy, and the errors in estimating falls of less than one-hundredth of an inch (one-tenth of a millimetre in the case of millimetre glasses) may well make a serious difference to the number of raindays reported at a particular station.

"More than one attempt has been made in the past to improve the pattern of the measuring glass with a view to overcoming this defect. Among the modified forms, probably the best known is the 'Camden' measure, which is used by several rainfall observers in this country. In this measure the glass tapers towards the bottom so that the graduations are more widely spaced than in the ordinary measure. Moreover a special graduation, ·005 inch, is engraved on the glass so that the question whether the rainfall shall be counted as ·01 inch or 'trace,' may be answered with confidence. The external diameter of the Camden is, however, uniform throughout its length, so that the lower tapered portion is surrounded by a thick wall of glass, and in taking readings at the lower graduations it is extremely difficult to avoid errors due to parallax. The advantages which the measure is intended to possess are largely discounted.

"Measuring glasses of a new pattern have recently been adopted by the Meteorological Office, and are now in use at certain official stations. The measure tapers at the lower end similarly to the Camden glass, but the walls are of uniform thickness throughout, so that the chief defect of the latter measure is overcome. Very fine limits have been laid down by the Meteorological Office with regard to the accuracy of the lower graduations, and it is possible to measure small quantities of rain accurately."[1]

The new measure is not provided with a base of any kind, a fact which might at first appear a disadvantage, but it is intended that the measure should be held in the hand when taking a reading.

In estimating how much water can be derived from a given area of ground a deduction of one-fifth must be made for evaporation; and according to the steepness and slope of the ground, the porosity of the soil upon which the rain falls, the quantity of vegetation, and so on, varying amounts of water will either penetrate, or, on the other hand, run over the surface and find their way into water-courses. In hilly districts the conditions are necessarily much more favourable for surface flow than they are on flat lands, and while, in the case of sand or gravel, the large bulk of the rainfall sinks into the ground, upon clay hardly any infiltration occurs.

In estimating the amount of water which can be relied upon from a given "catchment area," it has to be borne in mind that the quantity of rain which falls varies from year to year. Hawksley's rule is to the effect that the average of 20 years less one-third gives the amount of rain in the driest year, while this average plus one-third gives the amount of rain in the wettest year. On the same authority the amount of storage which should be provided is often taken as being given by the formula $D = \frac{1000}{\sqrt{F}}$, D being the number of days' supply to be stored, and F the mean, in inches, of the rainfall of three consecutive dry years, or, say, five-sixths of the average annual rainfall.

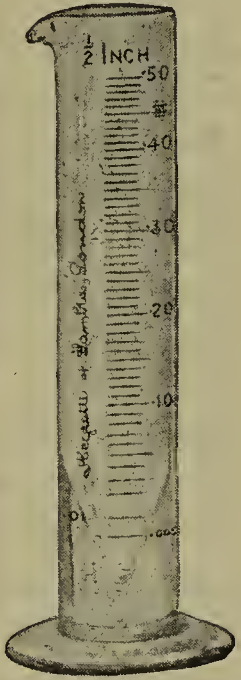

FIG. 19.
Camden Measure.

As regards the amount of water required for a given population, about 30 to 35 gallons per head is that usually found necessary in most large communities in this country. The actual quantity consumed, in the form of food and drink, per person is only about half a gallon, another half gallon would be required for cooking; considerably larger amounts are, of course, needed for washing and laundry purposes. The estimate given by Parkes was 12 gallons per head for ordinary domestic use, with 4 additional gallons for general baths, and 9 gallons for water-closet purposes and unavoidable waste. This makes a total of 25 gallons per head for ordinary household supplies, and leaves, on a basis of 30 gallons per head, only

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[1] See "Meteorological Magazine," Sept., 1924.

5 gallons for trade and municipal purposes. This quantity is likely to be found insufficient in many manufacturing towns, and gives but scant allowance of water for washing streets, fire extinguishing purposes, etc. The average amounts supplied in London have varied in recent years from 30 to 35 gallons per head daily, but some of this undoubtedly represents waste. In Glasgow and in a few other cities considerably larger quantities are supplied.

During the time of great scarcity of water, the summer of 1921, these estimates were reconsidered. The Ministry of Health held that an average of 16 gallons per head per day (exclusive of water used for trade purposes) was quite adequate in most towns under present conditions. They advocated arrangements for combination between water authorities for pooling their resources, and the use of additional sources of supply, including the supplementing of domestic supplies from sources which, in normal circumstances, would not be used, subject to special treatment (chlorination), carried out under the supervision of competent officers.

The use of potable water for manufacturing and sanitary purposes, when other supplies could be obtained, they discouraged, and strongly urged the collection of rain-water by householders. Intermission of supply, whilst useful for saving water where houses contain storage cisterns, they did not advise unless absolutely necessary. Wherever practicable, compensation water should be intermitted when not required for power or manufacturing purposes. Authorities were urged to consider the advisability of organising special measures for the detection and prevention of all forms of waste. Division of areas of supply into zones, in order to avoid unnecessarily high pressure, was suggested ; public warnings against waste were advised, and favourable mention was made of the possibility of replacement of defective washers by water authorities, free of cost to the consumer.

Rain-water is practically always collected from the surface of roofs. The yield is greatest from high-pitched roofs made of non-absorbent materials ; slates take up only about 1 per cent. of water before they are saturated, while different kinds of tiles absorb from 3 to 18 per cent. The first portion obtained from a roof during a rainstorm contains soot, bird droppings, and other such impurities lodging on roofs ; the use of a " separator " ensures the rejection of this portion, and also of water derived from light misty rains insufficient to remove the accumulation of dirt from a roof.

When possible, a cistern placed in one of the top rooms should be provided ; this enables the water to be supplied throughout the house systematically by means of pipes.

Rain-water is occasionally collected for domestic purposes, especially in country districts, where water has otherwise to be carried by hand from long distances. Owing to its softness, rain-water is especially useful for cooking and washing.

In towns, the rain while falling becomes contaminated by acids, sooty particles, and other impurities added to the air by the combustion of coal and coal-gas. An analysis and comparison with Thames water show the high results indicated.

	Town collected sample of Rain-water. Grains per gallon.	Raw Thames Water.	Filtered Thames Water.
Ammoniacal nitrogen	0·14	0·005	0·0002
Albuminoid nitrogen	0·015	0·011	0·0043
Chlorine	0·45	1·2	1·15
Oxygen absorbed from permanganate	0·22	0·147	0·059
Total hardness	3·7	16·3	15·6
Colour (mm. brown, 2-ft. tube) . .	160	71	19

Its use for drinking therefore is inadvisable. In country districts, however, after passage through an efficient filter maintained in satisfactory order, rain-water forms a pure drinking-water supply, being free prior to storage from any probable human fæcal pollution. Slow filtration through charcoal gets rid of its mawkish sooty taste.

Rain-water should not be collected or stored in wooden barrels or tubs; they soon become foul and serve as breeding-places for minute forms of animal and vegetable life.

In some sparsely populated districts, in the absence of a public water supply or the possibility of a private supply either superficial or deep at a reasonable cost, the population must depend for its water supply upon the collection and storage of rain-water; the area of roof space in such cases assumes importance. The slope of the roof must not, of course, be taken into account, what is material being the horizontal area covered by it. If the projection of the roof on a horizontal plane be taken at 60 square feet per person, and if the rainfall be 30 inches per annum and one-fifth (the ordinary allowance made) be deducted for evaporation, it will be found that the rain-water available only amounts to some two gallons per person daily.

In a number of instances, however, the circumstances allow of a considerably larger supply than the above example indicates and although the larger quantities supplied in towns are not available the quantity collected serves to supply the needs of the household (but not of farm animals).

Upland surface waters nearly approach rain-water in softness and purity. They are usually derived from the surface drainage of unpopulated or sparsely populated land and may require little or no purification before distribution. They contain more dissolved solid matters than rain-water and sometimes yield evidence of the presence of considerable quantities of organic matter of vegetable origin.

All surface sources of water supply, even if ordinarily free from the taint of sewage pollution, are open to accidental contamination, *i.e.*, by chance vagrants, pedestrians, etc.

In some towns in the north of England water derived from moorland sources has given rise to lead poisoning in persons who have consumed it. Several large English towns have provided themselves with water collected upon "catchment areas" in hilly districts, utilising lakes, and where necessary raising their water level, and causing the natural area of the reservoir to be thus considerably extended, by the construction of dams of masonry. These impounding reservoirs retain the excess water derived from the winter and spring rainfall so that it is available during the summer and autumn. To a less extent they retain the rainfall of wet years and make it available in dry years. Such gravitation supplies with their enormous storage reservoirs can take full advantage of floods occurring after scarcity of rain; where the water is derived from rivers and has to be pumped into reservoirs this advantage does not exist as the pumping capacity to be economically sound must bear a fairly close relation to the daily consumption of water.

In upland gravitation schemes of supply, storm water courses are frequently provided, so that when a flood occurs the worst water is prevented from entering the reservoirs and flows instead along the water courses on one or both sides of the reservoirs and so escapes down the valley. The ideal catchment area is free from human habitation and is covered with trees; the fewer the roads and footpaths the better. In this country we must be content to utilise a sparsely inhabited area with the minimal area of land under cultivation. When examining the sources of a surface water supply, either actual or proposed, the whole of the area should be examined and every stream traced from its entrance into the storage reservoir to its source. The drainage arrangements of every dwelling should be investigated to find out if they are likely to cause pollution of the nearest watercourse or if the drainage is carried by a drain beyond the boundary of the collecting area. The cultivated land should be visited to ascertain if the contents of the pail closets or of privy cesspits are used as manure.

Water from feeders which are undoubtedly free from contamination should be bacteriologically examined both during fine and rainy weather in order to ascertain the number and kind of bacteria normally present so that bacteriological standards may be established by which water collected from other parts of the gathering ground or from the reservoir can be judged. In this way sources of pollution which have escaped the notice of persons inspecting the watershed have been traced.

On moorland gathering-grounds the extent of the area covered with peat and the presence or absence of peat-bogs must be determined. Peat is usually found on the igneous and oldest rocks, the Cambrian, Silurian and Devonian formations and on the rocks of the coal measures. Water in contact with peat becomes acid, owing to the action of bacteria; the longer the water remains in the peat the more acid it becomes. Such waters are able to dissolve lead, the plumbo-solvent power depending on the quantity of acid present. Springs may be found yielding water containing sufficient carbonates to neutralise the acids in the peaty water, but the surface water will, however, be more abundant than the spring water after rainy weather and heavy storms.

Heavy storms wash out of the peat-bogs water which has long been in contact with the peat and is in consequence strongly acid; it may be found necessary to cut out special areas so as to run the very acid water to waste.

THE EXAMINATION OF WATER

There are certain physical characters presented by water to which attention must be directed. Thus, the extent to which *turbidity* is present should be noted. The turbidity is often stated in terms of a standard solution of saccharated carbonate of iron B.P. 1 gram to a litre of distilled water.[1] Anthony's turbidimeter is used. Some of the water may be allowed to settle, with a view to collecting sediment; the character of such deposited material may afterwards be made the subject of study in the way to be presently described.

Again, the *colour* of the sample is generally determined by examination of a portion of it in a two-foot tube, the estimation being made by looking through the column of water at a white surface. Burgess's apparatus is commonly used.[2] If the water be perfectly pure it is quite clear, or has a slight bluish or greyish tint; any variation from this, in the direction of yellowish or brownish appearance, raises suspicion as to the character of the water, though such variation may be due, of course, to the presence of peaty matter, or of salts of iron. The *lustre* of the sample of water is said to indicate the amount of aeration; it may vary from what is described by the terms *nil* or *dull* up to *vitreous*, or to the maximum brightness, which is termed *adamantine*. The *taste* of the water may afford information, though it is advisable to know something of the sample before making use of this test. Its main value lies in the fact that it facilitates detection of iron, which gives appreciable taste to water when present to the extent of only about one part in 400,000. Salt, on the other hand, may occur in very considerable amounts without causing its presence to be appreciated. When sea-water has soaked into a public water supply it has been detected and complained of when the amount of salt was not more than 20 grains per gallon; others have not noticed the salt until it has reached 50 or more grains per gallon. In the Sinai peninsula, where the water in the wells is often brackish, experiments showed that tea was palatable when the chlorides did not exceed 120 parts per 100,000, and medical officers came to the conclusion that 150 parts of sodium chloride per 100,000 was the limit which should not be exceeded in drinking-water to be used by the troops and that for general use 100 parts per 100,000 was a safe standard.

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[1] See Thresh, "Examination of Water and Water Supplies," pp. 277–279.

[2] See "Analyst," Vol. XXVII, No. 319, October, 1902.

What is ordinarily spoken of as the taste of water is mainly due to the gases dissolved in it. The most palatable waters are often those containing nitrates and carbon dioxide which may have been derived from objectionable sources as the nitrates and carbon dioxide are formed by the complete oxidation of sewage and manurial matter. Such waters are usually colourless, bright and sparkling and are in consequence much liked.

The sense of *smell* may be best applied after warming a little of the water, when it may be found that an odour indicative of putrefying organic matter can be distinguished.

When the supply is for domestic purposes it is often more important to investigate the source of supply thoroughly than to make chemical or bacteriological analysis of the water itself. These may indicate when a water is polluted and may on occasions indicate possibility of dangerous pollution, but they cannot be relied on to prove the absence of occasional contamination. A chemical analysis, however carefully made, can tell us little or nothing about the liability to contamination. By chemical methods gross pollution can be detected, but slight traces of sewage cannot be detected and larger traces may be confounded with harmless vegetable matter.

Pollution is frequently intermittent; a water generally of great chemical and bacteriological purity but liable to occasional contamination is eminently unsafe. By analysis, however, variation in character can be discovered, and whether the saline constituents are in quantity and quality harmless and unobjectionable or not can be determined. Also repeatedly unsatisfactory results from analysis cause a more extensive search for sources of pollution which can only be detected by excavations around the source of supply, a search which would never have been made had not the analytical results indicated danger.

Bacteriological examinations must be made to detect minute quantities of pollution by sewage or matter of manurial origin. The quality of a water supply is measured by the worst sample which can at any time be obtained from it.

CHEMICAL EXAMINATION

The sample of water for purposes of chemical analysis is usually taken in an ordinary "Winchester quart," which holds about half a gallon; the bottle must be thoroughly cleansed, rinsed out with a little hydrochloric acid, and then repeatedly washed until all traces of acid are removed. At the time of collecting the sample the bottle is usually again rinsed out with some of the water, a sample of which is to be taken, and is then filled. In conducting this process it is well to make sure that the sample is taken in such a way as to fulfil the conditions which are likely to be observed by persons having recourse to the source in question for their supply of water.

In the majority of cases all the information required to form an opinion upon the character of a water can be obtained by determining the chlorine as chlorides, the nitrogen as nitrites and nitrates, the hardness, the free and organic ammonia, and by testing for the presence of nitrites. When necessary these tests can be supplemented by ascertaining the total solids and the oxygen absorbed and by applying tests for the presence of salts of iron, lead and zinc.

The determination of the total solids affords a check on the results of the analysis; any large difference between the total solids and the sum of the chlorides, nitrates, carbonates and sulphates (the two latter judged from the hardness results) indicates the necessity for further examination.

The results are most conveniently expressed in parts per 100,000; to convert these results into grains per gallon these should be multiplied by 0·7.

Ammoniacal Nitrogen—The urine of men and animals on fermentation yields large quantities of ammonium carbonate; hence sewage is rich in ammonia. Some traces of ammonium salts, usually the carbonate, are found in most natural waters. By the distillation of such waters, with or without the addition of a little alkali, the ammonia is carried over in the distillate and is spoken of as "free" ammonia to distinguish it from a further quantity of ammonia which can be obtained by decomposition of the nitrogenous organic matter (brought about by adding a strong alkaline solution of potassium permanganate to concentrated waters) and continuing the distillation.

Nitrates by their reduction yield ammonia; a water containing nitrates which has been subject to the reducing action of ferruginous sands or of long lengths of metal pipes, may contain ammonia. Wherever the amount exceeds 0·004 part per 100,000 of "free" ammonia an endeavour should be made to ascertain its origin; the presence of 0·006 part makes the safety of the water doubtful. Considered together with the amount yielded by the organic matter present, the probability of sewage pollution can be judged. A figure in excess of 0·01 part per 100,000 occurring in a water containing an excess of organic matter almost certainly indicates sewage pollution unless the water is derived from upland surfaces.

In crude sewage the " free " ammonia may be almost ten times as great as the albuminoid ammonia, while in the effluent it is thirty times as great. Hence in most cases when a water yields more " free " ammonia than albuminoid ammonia, the indications are that the water is polluted with sewage. Decaying vegetable matter in water yields more albuminoid than free ammonia and yields this albuminoid ammonia slowly. Water yielding over 0·01 part per 100,000 of albuminoid ammonia if associated with free ammonia to the extent of 0·006 part must be looked upon with grave suspicion. If the free ammonia reaches 0·008 part, in the absence of proof that it is derived from a harmless source, recent sewage pollution is strongly to be suspected.

Chlorides—The presence of excess of chlorides and nitrates in water indicates that the water has contained organic matter presumably of animal origin but that it has been oxidised. Unless some of this organic matter has remained unoxidised or the bacteria which accompany it have not been removed by filtration through the soil, the water may be perfectly wholesome.

In this country agriculture is carried on to such an extent that it is practically impossible to obtain water from deep or shallow wells which has not been in contact with manured soil. The surface soil possesses such oxidising and purifying qualities, due chiefly to the presence of nitrifying organisms, and the subsoil usually filters so effectively, that practically the whole of the organic matter and bacteria derived from the sewage disappear before the water has travelled any considerable distance. The derivation of the chlorides in a water from sewage is shown by the simultaneous presence of nitrates in marked quantity and by the amount of both rising and falling together.

If the average character of the waters of a district, from which a particular sample is obtained, is known, the amount of chlorine present in the sample then affords a valuable indication of the likelihood or unlikelihood of the water being dangerously contaminated.

Four parts of chloride per 100,000 may as a rule be considered normal. In sea-water there are some 1,800 or 1,900 parts of chlorine per 100,000, and water obtained from tidal rivers, from deep wells near the sea coast, or from wells penetrating strata which contain deposits of salt, may contain considerable quantities of chlorine.

Oxidised Nitrogen—When the organic matter in water decomposes, the nitrogen is first converted into ammonia, and this becomes subsequently oxidised, with formation of nitrites and nitrates.

The formation of nitrites constitutes the first stage in the oxidation of nitrogen, and nitrites speedily tend to become further oxidised into nitrates ; it follows, therefore, that if nitrites are present nitrates are also likely to be found. Nitrates may, however, exist in water unaccompanied by nitrites. The presence of nitrites is indicative, as a rule, of recent pollution ; any water containing nitrites must be regarded with suspicion unless their presence is due to the reduction of nitrates by metals.

Many waters containing nitrates if allowed to stand in contact with iron, zinc or lead in pipes or cisterns, act on the metal, the nitrates being reduced to nitrites and ammonia. Practically the whole of the nitrates found in water are derived from oxidation of nitrogenous organic matter of animal origin ; vegetable matters by oxidation in the soil yield very little nitrates.

Though excess of nitrates and chlorides in a water indicate previous sewage or manurial pollution, yet if the sources from which it is derived are sufficiently remote their presence may be ignored. However a water cannot be recommended for domestic use which contains more nitrates than appears to be the normal in the best waters from that particular water-bearing stratum ; any excess necessitates a careful investigation of the source of the water. Bacteriological examinations should also be made, especially a day or two after a heavy rainfall, in order to ascertain whether both soil-purification and filtration are efficient. In any case a water which contains any excess of nitrates and which is liable to become turbid or opalescent after heavy rain should be unhesitatingly regarded as unsafe for domestic purposes.

Oxygen absorbed from Permanganate—The amount of readily oxidisable matter present is measured by ascertaining the amount of oxygen the water is capable of taking up from an acid solution of potassium permanganate, if necessary the amount taken up by substances of mineral origin present, such as ferrous salts, nitrites and sulphides, being first ascertained.

Although strictly speaking the figures obtained are neither an index of the quantity nor of the quality of the organic matter, yet as the amount of oxygen varies in different waters, being usually very small in pure waters and comparatively large in impure waters, the determination is not without value. As the total oxygen consumed varies greatly in the same water, the chief factors being temperature and time, the water under examination is usually maintained at 80° F. for three hours.

The following table devised by Frankland and Tidy gives standards generally adopted :—

AMOUNT OF OXYGEN ABSORBED IN 100,000 PARTS OF WATER

	Upland Surface Waters.	Other Waters.
Waters of great organic purity .	Not more than ·10	Not more than ·05
Waters of medium purity . .	,, ,, ·30	,, ,, ·15
Waters of doubtful purity .	,, ,, ·40	,, ,, ·20
Impure water	More than ·40	More than ·20

Of other examinations of water made, that to ascertain the amount of *dissolved oxygen* is the most important. It is of use in showing the extent of purification of a river, samples of water being taken from different points along the course of a river. The more nearly the water is saturated with oxygen, the better is its quality and the more efficient the process of "self-purification." A fully aerated water contains about 7 cc. of dissolved oxygen per litre; the amount varies according to the temperature and is about 6 cc. in summer and over 8 cc. in winter. Badly polluted water contains little or none. The amount of dissolved oxygen in the water of deep wells is not markedly affected by seasonal influences. In very deep wells the merest traces of dissolved oxygen are found. Dupré has suggested that the amount of dissolved oxygen in a water may be regarded as a test of the number of oxygen-consuming micro-organisms present in it; Thresh finds the result of such examinations far from reliable and considers that the desired information could be more definitely obtained by the ordinary methods of chemical and bacteriological examination.

Of late years the estimation of the dissolved oxygen has acquired a greater importance as it affords a test of the efficiency of bacterial beds in the purification of sewage; well-oxygenated effluents are generally found more satisfactory both as regards the degree of purification and keeping properties, *i.e.*, non-liability to putrefactive change.

Determination of Carbon Dioxide—Carbon dioxide may exist in water as free acid, or in combination in the form of carbonates or bicarbonates. The "free CO_2" and that in the form of bicarbonate (the "half-bound CO_2") together make up the "volatile CO_2"—that expelled from the water by boiling. The remainder is the "fixed CO_2"—that existing in the form of carbonate. A high free carbon dioxide content is deleterious to the piping system of waterworks; it corrodes iron, the effect being greatest with soft waters. A moderate addition of lime causes the deposit of a protecting layer of calcium carbonate.

BACTERIAL EXAMINATION OF WATER

An immense number of different species of bacteria may be found in water, but the majority are apparently quite harmless. Impure waters may contain from 10,000 to 100,000 bacteria per cc. and upwards. In exceedingly pure water, such as that derived from deep wells, very few bacteria are found, and by efficient filtration the number present in river and upland surface waters can be materially reduced. An estimate of the number of micro-organisms present (and capable of development upon the particular nutrient materials used) in measured quantities of the water affords a measure of the probability of the presence of pathogenic organisms and above all gauges the efficiency of filtration. When properly constructed and worked, there is no difficulty in producing with sand filters a water collected at the filter beds which will uniformly contain less than 100 micro-organisms per cc. capable of growing on gelatine at 20° C. in three days.

Information of more value is afforded by examinations to determine the presence of certain bacilli in definite quantities of the water. Much of our knowledge in this country on this subject is derived from Houston, Thresh and Savage. Three groups—B. coli, B. enteritidis sporogenes and streptococci are used very extensively as bacterial indicators of excretal and sewage contamination.

The B. coli group is by far the most reliable indicator of excretal pollution we possess, and its use is equally applicable for water, shell-fish, soil and other substances; in addition, it is the most practical, delicate and rapid test for the presence of excremental matter.

The other two indicators are chiefly of value for confirmatory purposes; streptococci are the least satisfactory as our knowledge of their distribution in nature is very incomplete. It is now agreed that there is a fairly well defined group of bacilli, B. coli, which have certain characters in common; belonging to this group is a bacillus, B. coli communis, found in human excreta, the identification of which in water is of special importance; as to the properties of this bacillus general agreement has not yet been reached.

Houston holds that the B. coli communis found in human fæces is usually "flaginac"; *i.e.*, it produces fluorescence in neutral-red broth, acid and gas in lactose broth, indol in peptone water and acid and clot in milk; an organism, however, which will produce acid and gas in lactose and indol in peptone water is excretal in origin.[1]

Thresh holds that the true B. coli communis may be "flaginac," "saginac" (saccharose being fermented),[2] or "aginac," but does not regard the "sagin" or "agin" groups as true excretal bacilli, although he considers that in any water containing members of the "sagin" or "agin" groups, members of typical groups will be discovered if a sufficiently large quantity of water is examined. He regards the excretal type not as a definite species but as one of a group because further subdivisions can be made by the use of dulcite, mannite, sucrose and other sugars and neutral-red solutions.

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[1] See "Studies in Water Supply," Houston, Chaps. IX and X.

[2] See also p. 358, Muir and Ritchie's "Bacteriology" (1919).

Pure waters, generally speaking, contain no typical B. coli in a majority of representative samples, and incidentally it may be stated that impure waters can be so purified as to yield similar results at a not unreasonable cost.

The test for the presence of B. enteritidis sporogenes in quantities varying from 10 cc. to 1 litre is useful, not so much as an indication of sewage pollution as of the presence of surface waters derived from land under cultivation.

The usual proportion of B. coli to B. enteritidis sporogenes present in water is from 400–2,000 to 1 ; considerable quantities of water must be examined if very minute traces of pollution are being sought for. Experience shows, however, that in a water known to be polluted the B. enteritidis sporogenes can usually be found in about 100–150 cc. of the water if the B. coli is detected in 1 cc. Seeing that the organism bears spores and has prolonged powers of resistance, any pollution which may have occurred may be so old as to be of no significance. The absence of B. enteritidis sporogenes from a large quantity of water is some evidence of purity ; pure waters practically never give typical positive results with 10 cc. and seldom with 100 cc. of water.

The presence of streptococci affords no evidence as to whether the contamination is recent or remote ; unless associated with other bacteria of intestinal origin their presence has no known significance. They are very rarely found in really good waters, but cannot always be found in undoubtedly polluted waters ; therefore if found in a water containing relatively abundant B. coli, all that can be safely held is that their presence strongly confirms the opinion that the water is polluted with sewage or manurial matter. If the spores of the B. enteritidis sporogenes are also found the evidence may be regarded as conclusive.

Bacterial Standards—In sewage B. coli number 100,000–800,000 per cc., streptococci 1,000–10,000 (?) and the spores of B. enteritidis sporogenes 100–2,000.

Water which gives no indication of the presence of typical B. coli in 20 cc., of streptococci in 50 cc. and of spores of B. enteritidis sporogenes in 500 cc. is at the time of examination so free from sewage pollution that it can be certified fit for drinking purposes, provided its source is known to be satisfactory. This standard is reached by water from all properly protected springs and most properly constructed deep wells. Savage, however, considers deep water supplies should not contain excretal B. coli in 100 cc. Deep well waters when uncontaminated contain few bacilli and no B. coli or other indicator organisms. The presence of B. coli with or without streptococci indicates pollution with surface water or other undesirable material.

Upland surfaces are generally used for grazing animals and are the home of many wild birds; their excreta contain numerous B. coli indistinguishable from human B. coli and the water from such sources contains these organisms in considerable numbers even when the gathering areas are remote from dwellings and free from all risk of contamination from human sources. Upland and moorland surface waters, collected in reservoirs, may be regarded as satisfactory if typical excretal B. coli cannot be found in 10 cc. and especially if the B. enteritidis sporogenes also cannot be detected in 250 cc.

Shallow wells, provided they are properly constructed, situated at some distance from highly manured land and their water does not become turbid after rain, yield water of a similar standard but they cannot be passed as satisfactory from the result of a single bacteriological examination as the soil filtration although efficient at the moment may break down at any time and without warning.

The absence of B. coli is no proof that a water is not seriously contaminated or liable to such pollution, more especially if the water is derived from the subsoil and drawn from springs or shallow wells.

Chemical examination may show that a water which from bacteriological results alone would be pronounced safe is in reality seriously polluted and evidently derived from a subsoil polluted by manurial matter.

It will therefore be seen that although even the B. coli test alone is of the greatest value a water supply should be finally judged by a summation of verdicts, geological, topographical, physical, bacteriological and chemical. The isolation of typhoid bacilli from water is acknowledged to be difficult, but Houston has isolated typhoid bacilli when so added to raw river water that only one was present in about 7 cc. of water; Gärtner bacilli he isolated when one was present in about 18 cc. of water.

Typhoid bacilli do not survive more than four weeks or so when raw river water is stored, a few days' storage suffices to destroy the vast majority. In well water contaminated by the fæces of a patient with typhoid fever the relatively large amount of organic matter added with the bacilli favours the viability of the organism, which may persist for much longer.

Contamination with B. typhosus usually involves a heavier contamination with B. coli, and as B. typhosus is much the more delicate of the two organisms the absence of B. coli is usually evidence of the absence of the typhoid bacillus.

The Microscopic Examination of the Sediment deposited from a sample sometimes yields evidence which serves to indicate whether or no the water has been exposed to risk of dangerous pollution.

A great variety of objects may be detected on microscopic examination of the material thus obtained. The nature of any mineral particles present may be recognised, partly by their appearance and partly by the effect upon them of various reagents. Vegetable matter, starch cells, linen and cotton fibres, spiral vessels, dotted ducts, and other kinds of vegetable tissue may be detected. Dead animal matter, remains of insects, fragments of wool, hair, scales, epithelium, etc., may also be found. Living forms are usually present in abundance; they consist, however, in the main of bacteria and microscopic fungi. Among larger living forms, diatoms, desmids, and algæ may be seen in water from streams and in well waters; amœbæ, infusoria (*paramœcium*, etc.), and hydrozoa, especially the fresh-water polyps, may also be met with. These are for the most part of importance, in so far as they imply the presence, in appreciable quantity, of nutrient material in the shape of organic matter, upon which such organisms are dependent for their existence. The same remark applies to still larger forms which may be exceptionally observed, such as small leeches, wheel animalcules, water fleas, water bears (*Tardigrada*), the larvæ of beetles, and the pupæ of insects. Under very exceptional circumstances evidence of the presence of certain parasites may be forthcoming. The eggs and segments of tapeworms may be detected; the eggs of round and thread worms, too, have been found in water in this country, and other parasites (*see* p. 145) may be found in drinking waters obtained in foreign lands. The most significant of the microscopical objects likely to be met with in samples of water designed for drinking purposes, and obtained in this country, are those which suggest the probability of sewage contamination; such are muscle fibres, fat cells, starch grains, epithelium, etc. If such objects as these be discovered the water must be regarded with the gravest suspicion.

In the absence of sand filtration a richly varied and abundant fauna can exist in water pipes. Before sand infiltration of the water from the Elbe live fresh-water shrimps and water wood-lice passed through the house water taps and the pipes leading to and from the house cisterns in Hamburg were not infrequently stopped up with eels and fragments of Polyzoa. Examples of fifty genera belonging to most of the main groups of the animal kingdom were recovered; the Polyzoa and the Sponges being by far the most important, the next being Mollusca and then at some distance Crustacea.

Similar troubles have occurred in this country in water supplies derived from upland surfaces. The remedy is sand filtration which acts by cutting off the food supply (diatoms and débris) of the fauna. In the plant world the chief offender is Crenothrix, an iron bacterium which infests both reservoirs and pipes of waterworks and causes pipe obstruction, making the water red and turbid and imparting an unpleasant smell to it.[1]

The Purification of Water—The ideal way of purifying water is to distil it, and this plan is adopted on the largest ships. On the largest ocean-going liners and battleships the regular demand for drinking-water may be as much as 5,000 gallons a day; with due precautions this water can be obtained free from grease and salts by the distillation of sea-water.

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[1] See "The Biology of Waterworks," R. Kirkpatrick, British Museum Economic Pamphlets, No. 7.

The next best way is to boil the water. So far as is known, all pathogenic bacteria which have been found in water are destroyed by exposure for some minutes to boiling temperature.

The boiling of water deprives it of the dissolved gases and so makes it less palatable. A perfectly safe rule is to bring three parts of water just to boiling point and add one part of unboiled water; the temperature of the mixture will be at least 75° C., a temperature more than sufficient to kill the typhoid bacillus within five minutes.

If for any reason it is desired to render water absolutely sterile it may have to be subjected to more than one boiling process, as any spores present are able to resist the action of boiling water for a considerable time; reliance must therefore be placed upon first affording the spores an opportunity of sprouting, and then destroying the less resistant bacteria which develop from them.

The destruction of spores of bacteria—complete sterilisation—is almost impracticable and probably unnecessary; the elimination of bacilli—partial sterilisation—is feasible. As we have seen, the death of the organisms causing epidemic water-borne disease, *e.g.*, the typhoid bacillus, may reasonably be inferred from the destruction of B. coli; sterilisation of water has therefore come to mean the killing of B. coli.

Much of the purification of large water supplies which takes place occurs in connection with river water. The first of the processes after abstraction from the river is often storage. The factors which make for the purification of water when stored are sedimentation, equalisation and devitalisation.

(i) Sedimentation. Although this process by itself is insufficient to produce the desired results yet its importance is considerable; even allowing the water to stand for less than 24 hours has a marked purifying effect.

(ii) Equalisation. The quality of a river water varies enormously from time to time; storage on purely physical grounds smooths over abrupt changes in its quality. Even although micro-organisms causing water-borne diseases may only occasionally be present they may occur in such numbers as to be a source of real danger, but when diluted with non-infected water the final mixture may be reasonably safe.

(iii) Devitalisation. Houston records that in one experiment the storage of Thames water for fifteen days brought about a percentage reduction in the gelatine, agar and bile salt agar counts of 95, 84 and 88 respectively. Judged by the B. coli test the water was improved at least one hundred times.[1]

His work has shown that the destruction of the organisms of typhoid fever and cholera is merely a question of time, although the period required varies with the temperature and is influenced by the prevalence of competitive organisms or their products. Several weeks' storage may be required, but for all practical purposes provision for thirty days' storage is ample when dealing with sources of supply comparable to those of London.

Temperature is an important factor bearing on the vitality of the typhoid bacillus in river water. Experiments carried out at temperatures ranging from 0° to 37° C. indicate that the lower the temperature the longer does this bacillus survive; this effect, however, is not marked during the first and second week, and if the water were stored for, say, four weeks, the question of temperature becomes one of almost secondary importance. In the cold months of the year—November to March—therefore it is especially desirable that water should be adequately stored before filtration.

The greatest danger in connection with storage is that some polluted water will, at times, get by the reservoir or flow through it by some short cut and so reach the consumer before it has been stored for a sufficient length of time. The inflowing water should be roughly strained; the inlets should be as far from the outlets as possible, and so arranged that the water does not pass directly from the inlet to the outlet leaving other parts stagnant. Construction in compartments has several advantages; it provides better opportunities for uniform mixture, rest and sedimentation, and allows of cleansing out in sections.

Storage has the additional advantage of reducing the hardness. A possible disadvantage is that at times algal and other growths develop to such an extent in the reservoirs as to interfere seriously with filtration; in some cases the water although innocuous may acquire in consequence a most disagreeable fishy or oily taste and odour. Copper sulphate is used to combat the growth. As a last resort potassium permanganate is added to the water as it passes into supply to remedy the tastes and odours.

Sand Filtration—Efficient slow filtration through sand can be relied upon to remove about 98 per cent. of the bacteria present; at the same time it affords opportunities for biological purification. Improvements in methods of preparing and washing filter sand have rendered it possible to instal adequate sand filters at a moderate expense.

The arrangements of such a filter are exemplified by those used by the Metropolitan Water Board. The water from the Thames, after storage, is conducted to the surface of filter beds composed of fine sand 3 feet in depth lying on gravel, fine above but coarse below, depth of 3–8 feet. Water passes through these beds into the mouths of pipes, which lead to a well from which water is pumped to the various reservoirs for the several districts.

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[1] "Study of Water Supplies," p. 78.

When a filter is first used it merely strains out the suspended matter but in two or three days a slimy layer forms on the surface of the sand and true filtration commences. The film is made up of several elements; it is a felted sheet of interwoven filaments of green and blue algæ with its meshes filled by diatoms with their siliceous frustules and gelatinous envelopes; innumerable bacteria are scattered throughout the whole mass. Sedimentation takes place in the pores of the filtering material to whose fixed particles the suspended particles adhere. The saprophytic bacteria present split up the albuminoids into their simpler constituents, lower in the film the nitrifying bacteria are at work. A stratum of decomposing organic matter intervenes between the film and the sand.

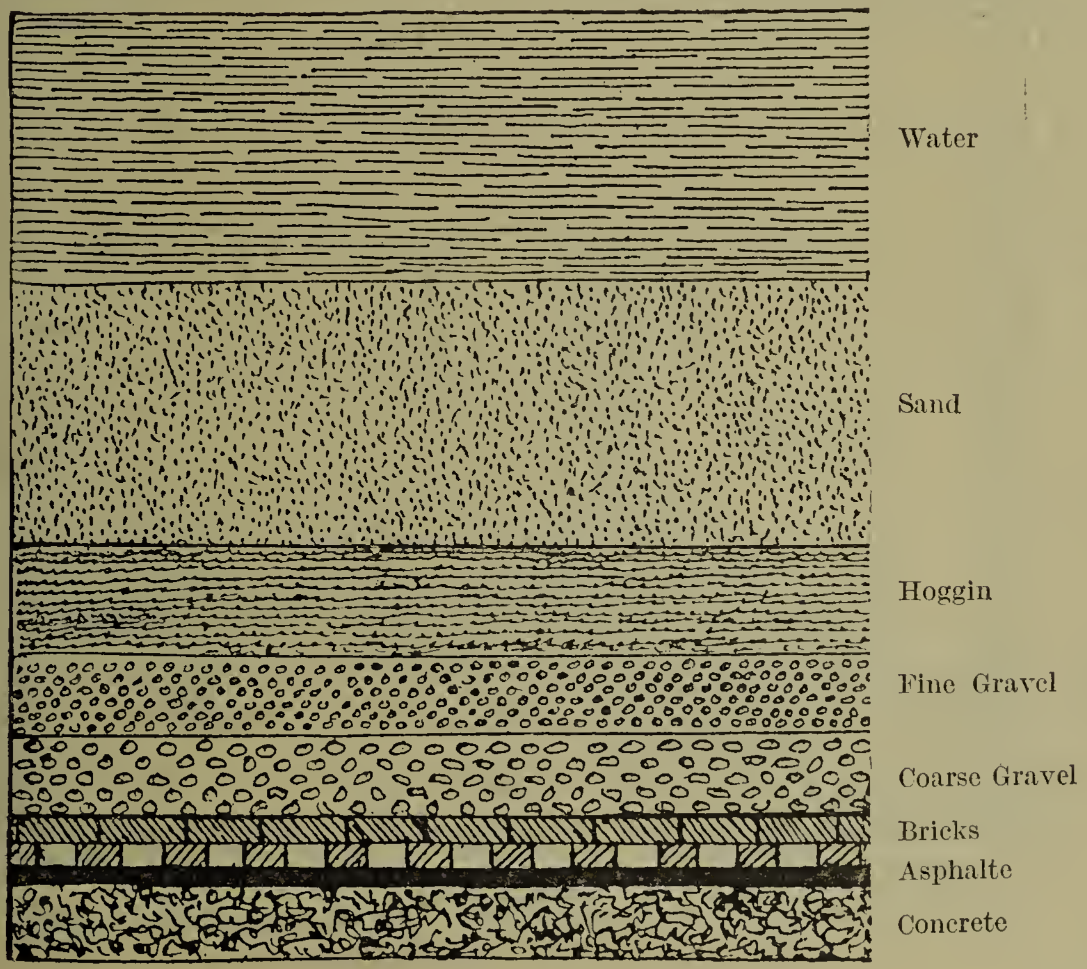

FIG. 20.—Section of Filter Bed.

With the lapse of time the interference of the film with the rate of filtration becomes so considerable that it has to be removed. This is effected by scraping the surface of the sand and supplying fresh sand, or in some instances the plan adopted is to wash the sand removed, with water from a hose, and to then re-apply the sand to the surface of the filter. After scraping, the water yielded by the filter is, for a time, rich in micro-organisms; the filtrate should not have access to the filter-well, which supplies the reservoir, until the slimy deposit on the surface of the sand has had time to again form. The rate of filtration should not exceed 100 millimetres (200,000 gallons per acre) per hour; the thickness of the sand should never be less than 30 centimetres; each filter should be bacteriologically tested every day, and the water supplied by any filter which was found to yield more than 100 micro-organisms per cubic centimetre should be rejected. Where such precautions are adopted, the risk of spread of disease by use of water which has been previously exposed to sewage contamination can be materially lessened, but there is always the chance, that some interference with the process of filtration—*e.g.*, in times of frost, and in connection with the scraping of the surface of filters and their immediate use without special precautions after such scraping—may permit of the passage through the filter of typhoid or cholera organisms.

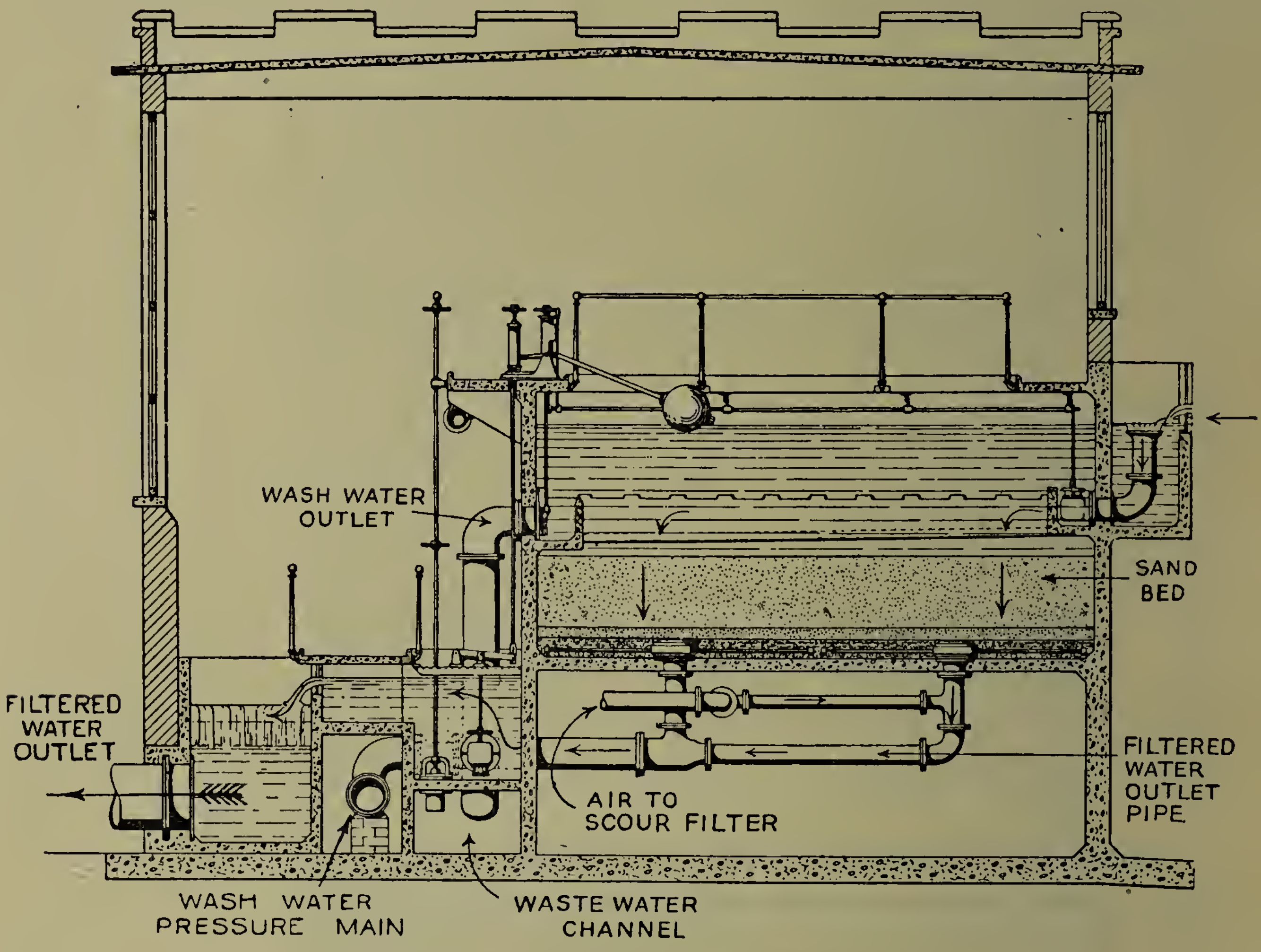

Fig. 21.—Paterson Rapid Gravity Pressure Filter.

The ordinary rate of filtration by sand filters in this country is about 2 to 3 gallons per square foot per hour. More rapid filtration through sand is carried out by so-called mechanical or pressure filters. The water is passed through a layer of sand so arranged that when dirty it can be mechanically washed by a reversed current of water aided sometimes by other appliances.

The Jewell filter, delivering 120 gallons per square foot per hour, and the Paterson filter 80, are of this type; they differ chiefly in the method employed to cleanse the sand bed.

In the U.S.A. 70 per cent. of the water supplies are purified by mechanical filtration; there the quantity and nature (clay) of the substances present in the water require the use of coagulants and every rapid filter plant of any size is provided not only with a coagulation tank but also with a sedimentation tank.

In the Puech-Chabal System of Multiple Filtration in use at a number of waterworks in France, Germany, India, and in a modified form at Sunbury-on-Thames and Bamford (Derbyshire) the water passes at a decreasing speed through a series of filters ("*dégrossisseurs*") of successively smaller sized gravel, from the size of walnuts to that of small peas; the depth of the straining material and its area are increased in each successive filter or row of tank filters. By these changes, and the diminishing size of the materials, the rate of passage of the water is lessened and more time is allowed for deposition as it advances. In addition to the coarser particles strained out in the *dégrossisseurs*, some of the finer suspended matter is held up by the slime coating which forms on the gravel. The water in most of these installations then passes through coarse sand pre-filters and the process is completed by using fine sand beds.

Sterilisation—Sterilisation processes are auxiliary, although they reduce the number of bacteria in raw waters, especially those with but little suspended matter; to obtain the full effect they should be applied to clear water, *e.g.*, filtered water. Chlorine in one or other of its forms and lime are used for this purpose.

Early in 1905 during the water-borne epidemic of typhoid fever Houston sterilised the Lincoln water supply by means of "chloros," an alkaline solution of sodium hypochlorite containing about 10–15 per cent. of available chlorine. On account of the large amount of organic matter present the dose employed was correspondingly larger —one equivalent to one part of available chlorine in one million. Bleaching powder is used at the Staines works of the Metropolitan Water Board. The amount of hypochlorite needed depends upon the quality of the water to be treated and the duration of contact. So wide a range of dose as 0·2 to 1·0 part of available chlorine per million parts (6 to 30 lbs. of bleaching powder containing 33 per cent. available chlorine to each million gallons) may be required; not less than five hours' contact should be given. When the water is near the freezing point sterilisation with the minimum dose capable of effecting sterilisation (*i.e.*, the dose which leaves no taste) requires a contact of from twenty-four hours to forty-eight hours.

Chloramine (NH_2Cl), produced by the action of ammonia on bleaching powder, is held to be the cheapest source of chlorine available for this purpose: like bleaching powder it can only be successfully used at large works where expert supervision is forthcoming.

Chlorine, obtained from the liquefied gas, is now widely used for small installations. The Wallace-Tiernan chlorinator can be regulated by hand or automatically so as to allow a definite quantity of the gas to be added to the water as it passes into the main; in one form of the apparatus an aqueous solution of the gas is added. Experiments carried out by C. R. Avery [1] show that if a normal water supply be treated with the same amount of available chlorine and provided proper mixing takes place, the disinfection in either case will be the same.

The removal of excess of chlorine can be effected in large installations by storage, preferably with aeration, or if part only of the water supply requires chlorination by admixture with pure untreated water. For eliminating excess of chlorine used, for instance, to sterilise the water in an impure well, sodium thiosulphate may be added after the chlorine has had long enough to do its work. For small water supplies, the passage of the water through charcoal is held to be best.[2]

Many persons object to the addition of chemicals to drinking-water; this objection is not made to the use of lime doubtless owing to the general knowledge that salts of lime are present in most waters. The matter of taste is one of much importance, the margin between successful sterilisation and a tasteless water is by no means great, and much vigilance must be observed to apportion the dose to meet every varying circumstance.

The Excess Lime Method—In the ordinary lime softening process as commonly practised, quick lime or slaked lime is added to the total bulk of the water to be softened. It is always added in amount purposely calculated to be rather less than is needed to combine with the bicarbonates present, *i.e.*, just short of removing the whole of the temporary hardness. Any excess of lime re-hardens the water; it is also undesirable to give the consumer lime-water to drink. In the excess lime method part of the water is purposely overdosed with lime so as to bring about a known bactericidal effect and then after a suitable interval this is mixed with enough untreated, *i.e.*, unlimed water to combine with the excess of lime. The dose of lime required for sterilisation purposes depends primarily on the degree of temporary hardness of the water, the degree of its impurity, and the duration of contact.

After the theoretical amount of lime required to combine with the bicarbonates has been calculated an additional 2 parts per 100,000 is required for bactericidal purposes. Time is necessary for sterilisation and, within certain limits, the longer the time allowed the smaller the dose of lime required for bactericidal purposes; at least 5–24 hours' contact should take place.

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[1] Provincial Board of Health, Ontario, Canada, Annual Report for 1914.

[2] Savage, Public Health, September, 1917.

Other methods of sterilising water are the use of heat, ozone, and ultra-violet rays. Sterilisation by heat is the ideal method bacteriologically, but it is too costly. Ozone can be used successfully for the destruction of pathogenic organisms in water, but it is also expensive, and in addition is not suitable for waters containing much oxidisable and suspended matters. Sterilisation by ultra-violet rays has been much advocated but it has still to be shown that the method can be adopted on a large scale.

River Water—The water of rivers is derived from three sources—surface water, subsoil water and the water of springs in its bed. Many large towns derive their supplies from streams liable, in a greater or less degree, to pollution by trade effluents and raw sewage, or by sewage effluents which have undergone more or less satisfactory forms of treatment before being discharged into the water course. Moreover, river waters are, as a rule, hard waters, and they are thus ill-adapted for manufacturing purposes, and are subject to other disadvantages incidental to the use of hard waters.

Rivers purify themselves to some extent by the gradual sinking of particles of sewage, forming the mud on the bed of the river, and by taking up oxygen from the air at the very large common surface which is much increased at weirs owing to the spray formed there.

The purity of the water varies according to the season of the year. The river Thames, for example, is purer in summer than winter when the heavy rainfall washes impurities of all kinds into the river. Some come from manured soil and flooded sewage farms; others from storm water sewage overflows. The increased velocity of the river not only interferes with the normal settlement of suspended matters, but constantly disturbs the suspended matters which had previously collected in its bed.

In the summer much of the water in the river is derived from underground sources and has in consequence been stored and filtered by Nature. Again the storm water sewage overflows, which in flood time discharge unpurified or imperfectly purified, filthy water into the river, are less often in operation. Moreover many of the sewage farms may be dried up and in consequence discharge no direct effluent into the river. Again the slow flow of the river no longer disturbs its bed and any suspended matters in the water are deposited in the more stagnant reaches.[1]

Water plants and forms of animal life present in the river materially assist in the purification of the water; sunlight exerts a baleful influence on any micro-organisms present and promotes the growth of vegetation which yields dissolved oxygen in large quantities; these factors are more effective in summer than in winter. The Rivers Pollution Commissioners, however, as the result of their inquiries, were led to the conclusion "that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidisation."

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[1] "Rivers as a Source of Water Supply," Houston.

River water which is to be treated and rendered potable should be abstracted from the river as far as possible when the flow is quiet. Pathogenic bacteria are more likely to be present in river water during floods than under more normal conditions, and so it seems prudent to exclude either partially or wholly such flood water from storage reservoirs. In the forty-ninth, fiftieth, and fifty-first weeks of the year 1894 there was notable increase in the number of notified cases of typhoid fever in London, and this increase followed shortly after the occurrence of exceptional floods in the Thames and Lea valleys in the forty-sixth and forty-seventh weeks of the same year. The water consumed immediately after the occurrence of these floods contained an excessive amount of organic matter.

In many districts effluents from manufactories, quarries, mines, etc., cause more pollution of rivers than sewage. Inspections are made to discover infringement of the Rivers Pollution Act, either by the casting in of solid refuse or the excess of harmful liquid effluents. The existence of by-passes enabling untreated manufacturers' refuse to be conveyed to the river is obviously unsatisfactory; steps should be taken to secure their removal whenever possible.

Wells and Springs—Water drawn from the ground by wells or taken from springs is now often termed "ground water"; this source of water is the main one relied upon in sparsely populated areas. Nearly one-half of the water derived from underground sources in England and Wales is obtained from the chalk.[1]

Solid chalk is too dense to allow of percolation; the water travels chiefly through fissures and polluting matter is in consequence often carried very considerable distances. Swallow holes—funnel-shaped cavities—are common on the surface of chalk and often lead to the pollution of wells.

The lower oolites rival the chalk as a source of water; they consist of beds of shelly limestone and marly clay. The same danger of polluting matter being carried long distances exists as owing to the compact structure of limestone water can only travel through and accumulate in the fissures and passages which are natural seams or cracks enlarged by gradual solution and removal of the rock by the passing water. These crevices are often continuous for miles.

The lack of porosity of this rock, however, results in failure to hold the abundant winter flows necessary to maintain the supply through summer droughts. Obviously limestone waters are not well filtered by Nature and their consumption has at times given rise to typhoid fever.

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[1] Information as to the water-bearing strata and the characteristics of waters derived from these strata is given in Rideal's "Water Supplies," see p. 248.

The Triassic Rocks composed of coarse-grained (New Red) sandstones are the remaining chief source of water supply. The sand granules of which they are composed are cemented together by calcium sulphate and carbonate; through this cementing material the water flows, it is in consequence very hard and much of the hardness is permanent.

"Porous rocks absorb a varying amount of water—up to about 25 per cent. of their weight—before they become saturated. When this state is reached the water begins to rise in the stratum resting on the impervious rock or clay beneath, and continues to rise until it finds some outlet for escape, either as a visible spring or an underground channel flowing over the impervious layer into a pervious and unsaturated one below it. The height which the water attains is termed the line of saturation or water-line, and is not always horizontal since the resistance of the rock to the flow of water varies from place to place" (Rideal).

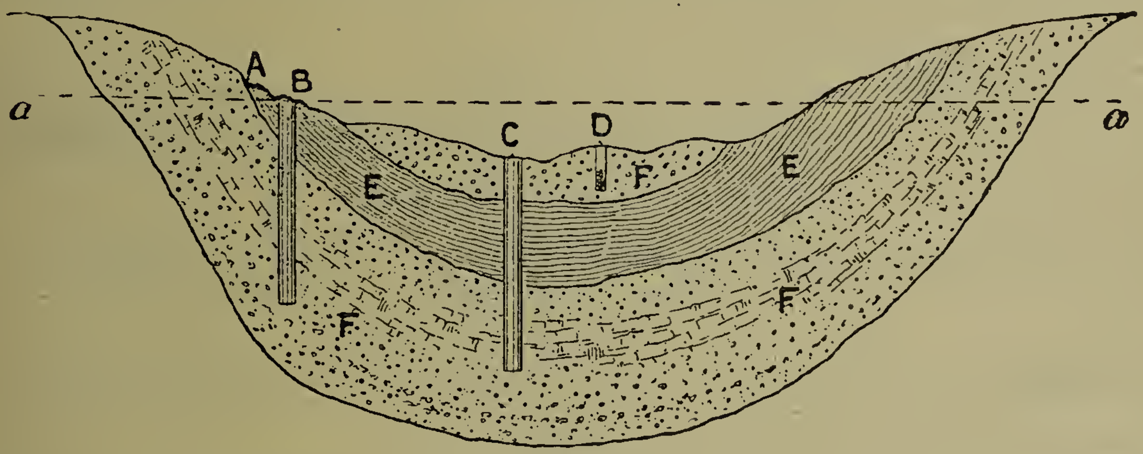

FIG. 22.—a - - - a, line of saturation, or level of underground water in deeper pervious strata, FF. A, spring cropping out above impervious strata, EE. B, deep well, and C, overflowing artesian well, bored through impervious into pervious strata, FF. D, shallow or surface well, sunk into overlying pervious strata, F.

A well such as that shown in Fig. 22 at D, which is merely sunk into a superficially lying porous bed of (post-tertiary) sand or gravel, containing water held up by an underlying impermeable layer, is termed a *shallow well*; such shallow wells are usually less than 50 feet deep.

The amount yielded by the sand or gravel deposit depends upon the rainfall, the evaporation from the surface of the ground and upon the amount of storage in the pores of the soil; abundant vegetation increases the quantity available. Most of the available yield is collected during the winter when evaporation is slight; the supply throughout the summer is maintained by the reserve thus accumulated.

The shallow wells, which formerly served for the supply of a large part of the population, and which are still common in rural districts, were not constructed with a view to preventing the entry of water, which had not been adequately filtered by the material surrounding the well. They for the most part either possessed no special lining of brickwork at all, or were merely "*dry-steined,*" the lining of brickwork being arranged in such a way as to secure a maximum yield of water. They were thus subject to pollution by surface drainage, and they were in many instances situated in close proximity to cesspools and drains. They were, moreover, liable to be contaminated by receiving impurity through the mouth of the well.

Shallow wells have been shown in many instances to have acted as agents for the dissemination of disease; they are so often contaminated that their probable impurity can be taken for granted. A cursory examination often suffices to show that pollution is possible; at other times the well must be opened up, and possibly the ground in the vicinity, to search for defective drains, cesspools, etc., within the drainage area.

The extent of this area depends upon the nature of the subsoil, upon the depth of the well, upon the depression of the water-level produced by the abstraction of the largest quantity of water required in a day and upon the direction of the flow of the ground water.

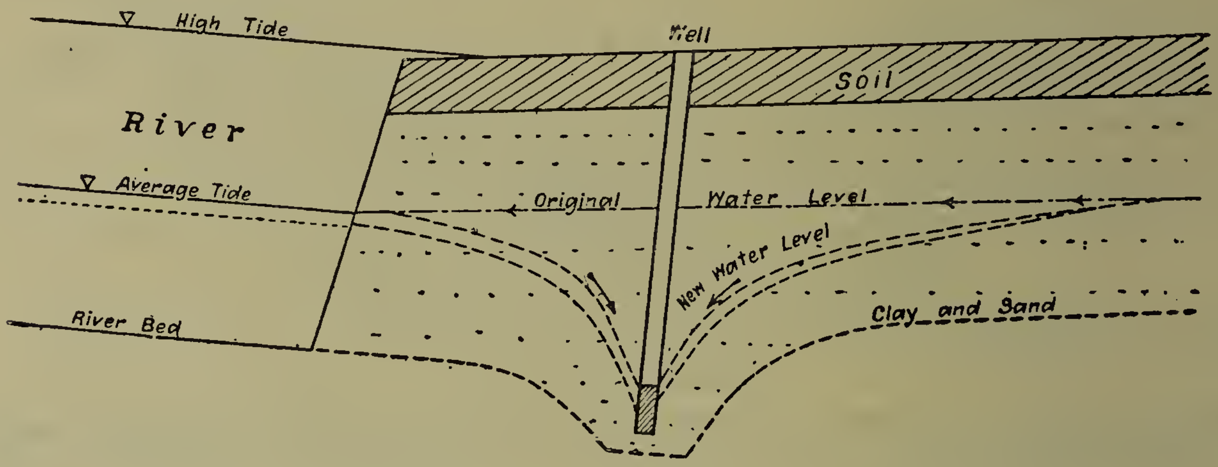

FIG. 23.—Water saturation line; showing how it is lowered by a well.

The more porous the subsoil, the larger the drainage area or area of depression of the subsoil water produced by the abstraction of water. Thresh considers that this area must always be regarded as not less than the area of a circle the radius of which is twenty times the depression of the water level produced by pumping; in running sand and fissured rocks it may be greater.

The surface of the ground water around a well when depressed by pumping has the form of an inverted cone, the sides near the well being steep, and gradually rounding off into the nearly horizontal surface of the subsoil water. The velocity of flow of the water at any point towards the well varies with the distance of the point from the well, decreasing more rapidly than the inverse of the square of the distance. At a certain distance away, in the absence of fissures, the movement of water through the soil is slower than the rate of filtration through sand in any artificial system of water purification.

The depth of the ground water must also be considered; the nearer this approaches the ground surface the greater is the risk of contamination. If the level of the ground water at any time approaches within two or three feet of the surface it will be almost impossible to render the water safe unless the whole of the area of depression is protected. Where the highest point reached by the ground water is 60 or 70 feet from the surface, and the ground is compact, percolation will be so slow that purification is ensured before water from the surface reaches this level; in such a case a very limited protection area is necessary. Actual tests—the driving of tubes around a well—are necessary in order to determine the zone of depression. Even in fairly compact sand and gravel beds there are lines of least resistance along which the water flows and this direction may be very different from that anticipated from the contour of the locality.

In tracing sources of pollution of wells, both shallow and deep, a strong alkaline solution of fluorescin, with or without brine, or a solution of common salt alone, is poured on the suspected place and the presence of the colour or any increase in the amount of chlorides in the water ascertained. Ammonium chloride is even better for the purpose as a small increase of saline ammonia is more easily detected than a corresponding increase of chloride. Lithium chloride recognisable by its crimson colour in a Bunsen or spirit lamp flame has also been used. These substances are all liquids and except for a certain amount of mordanting or absorption can pass through materials which would arrest bacteria. A positive result when they are used merely shows that a flow occurs between the place tested and the well, it does not prove that contamination by bacteria has occurred, since these may have been removed by the soil. A further test is therefore sometimes made using an insoluble substance such as Prussian blue or starch suspended in water, but even these are liable to deposition; when wheat flour was used to trace the source of pollution of a water supply at Lausen (Switzerland), it was shown that the soil removed starch granules but not typhoid bacilli. The most conclusive test is to add to the suspected source of contamination cultures of easily recognisable bacteria such as B. prodigiosus or B. violaceus.

The water from shallow wells, although impure, is often bright and sparkling in appearance, and pleasant to the taste. As a rule the water is hard; not infrequently much of the hardness is "temporary." The organic matter may be excessive, and the amount of oxidised nitrogen high.

Calcium and sodium nitrites and nitrates are often present in polluted surface-well water. Wells sunk near cemeteries are apt to contain excess of ammonia and organic matter; if the cemetery has been long disused these impurities may exist in only small amounts, but the quantity of nitrates or nitrites is likely under these circumstances to be considerable.

If a shallow well is used at all, it should be placed at a distance from sources of pollution, be protected against surface washings, *i.e.*, be provided with a coping to prevent unfiltered surface washings reaching to the interior, and be closed with a dust and waterproof cover. A pump should be fitted; this prevents filth being carried into the well by the rope and bucket. The sides of the well, for at least 20 feet from the surface, should be constructed of brickwork, set with hydraulic cement, so as to be impervious to water; iron cylinders are sometimes employed in the upper part of the well. Koch recommended that such iron tubes should be used, and that the space surrounding them should be completely filled in with clean gravel or sand.

Fig. 22 also represents an ordinary deep well B penetrating through the impermeable layers EE, and tapping the water-bearing strata FF.

Deep wells are sometimes carried as far as 1,000 feet or more below the surface. They are usually constructed by digging to some depth, and then boring until the strata it is intended to reach are tapped; precautions must be taken with a view to rendering the upper part of the well impervious, so that water from the deep strata only can have access to the well. In many instances horizontal adits are driven from the bottom of an excavation, with a view to penetrating water-bearing strata; the amount of water obtainable is likely to be considerably increased when an adit strikes a fissure in such strata. The various springs tapped are examined to ascertain whether they should be sealed off or admitted.

The excavation or boring must obviously be carried below the saturation line in order that the water may stand up in the well. Pumping will lower the line for a considerable distance around, and not only may drain adjacent wells, but if continued at a rate faster than the surface water can percolate through, may exhaust the entire stratum.

In 1835 the famous well of Grenelle was bored in Artois, in France, through the superficial strata into the underlying pervious strata, and the reservoir of water in the latter was thus tapped. Since that time many of these deep "artesian wells," as they are called, have been constructed, and if the point at which such a well is sunk be situated in a valley, having beneath it underlying pervious strata so disposed as to form a kind of basin, the level of the underground water in these strata may be considerably higher than the level of the mouth of the well. Thus the water in the well at Artois rose some 60 feet above the surface of the ground when the boring had reached a depth of about 1,800 feet.

The way in which this comes about is illustrated in Fig. 22, in which C is an overflowing artesian well, the mouth of which is considerably below the level *a - - - a* of the underground water in FF.

The water from a deep well yields, as a rule, very little organic matter, but it may contain iron and mineral salts in considerable quantity, and it is apt to be a hard water. Chalk water and waters from the oolite are hard, but their hardness is mainly temporary, and they are usually bright, sparkling, and charged with carbon dioxide. In limestone and sandstone waters the total hardness is generally high, and there may be a considerable amount of permanent hardness. Deep-well waters may contain such quantities of magnesium or calcium sulphates, or other salts, derived from the strata through which the water passes, as to render them unfit for drinking purposes. Excess of nitrates may be found in well water, apart from previous contamination with organic matter, in cases in which nitrates are present in the soil and can thus be dissolved out of it by the water. Occasionally very large amounts of saline ammonia are found in wells in the greensand.

Deep wells are usually perfectly safe sources of water supply. In the rare event of the yield of an impure water the origin of the pollution is usually found near the surface ; the upper portion of the well and the surface of the ground near by should be examined. If the outcrop of the water-bearing stratum is not far away possible sources of pollution should be sought for on this surface.

Owing to the expense of sinking deep wells and the speculative result they seldom constitute individual supplies to houses ; they are utilised largely for trade purposes and for supplying isolated institutions, asylums, prisons, schools, etc. The quantity of water yielded by them is likely to prove insufficient for large populations, though they are in many instances employed to supplement supplies derived from other sources.

Land or superficial springs are common on slopes where the end of the stratum has been exposed by denudation or by a fall. They are fed by subsoil water at a higher level ; sinking into the earth it reaches an impermeable stratum of clay or dense rock and flows down above the stratum. They are almost always intermittent. Attention when searching for sources of pollution should be directed chiefly to the upper side of the spring.

When water from a higher level passing in a water-bearing rock meets a fissure or crack in the overlying strata, it is forced up to the surface and forms a *mainspring*. A mainspring is also formed when a water-bearing rock is cut across, as at the edge of a valley.

The water has usually travelled a long distance before it reaches the spring ; owing to the large bulk of water in the strata, there is almost always a continuous flow. In sandstone, chalk and limestone strata the natural filtration of the water ensures its purity but the fissures give rise to the same possibility of pollution as in the case of wells.

Domestic filters were at one time largely recommended and used with the object of purifying water. The fact that wool, flannel, a piece of sponge, charcoal in powder or compressed into blocks, and certain compounds of iron, possess the property of removing impurities from water, was noted, and here, it was thought, was a means ready to hand of enabling consumers of water of doubtful character to protect themselves against any possibility of incurring risk. Many forms of domestic filter were designed. In some of them the materials used were those above mentioned, in others various patented preparations were employed; the principle relied upon was, however, for the most part, the same in all these filters. The immediate result produced was in many cases satisfactory, but it was found that after a time the filter failed to improve the character of the water.

Recent investigations have shown that these forms of filter, as ordinarily used, are a source of danger rather than of security. The filter becomes in many instances an actual breeding-ground for organisms, and under these circumstances the water, after filtration, may be more highly charged with impurity than was originally the case. Animal charcoal is a particularly unsatisfactory filtering agent, as it speedily loses its property of oxidising dissolved organic matter, and, moreover, adds to the water passing through it phosphate of lime, and thus renders it a medium favourable for the growth of bacteria. Filters which contain spongy iron, polarite, asbestos, etc., are less open to objection; again, silicated carbon and magnetic carbide are materials which have been recommended for use in filters. In Bischoff's spongy iron filter, spongy iron and oxide of manganese are employed, an asbestos cloth being also used to prevent impurity passing through the filter. No reliance can be placed upon the continuous action for a length of time of such filtering media, and they can hardly be recommended for the purpose of tiding over emergencies; they should in any case be freed from impurity before freshly bringing them into use.

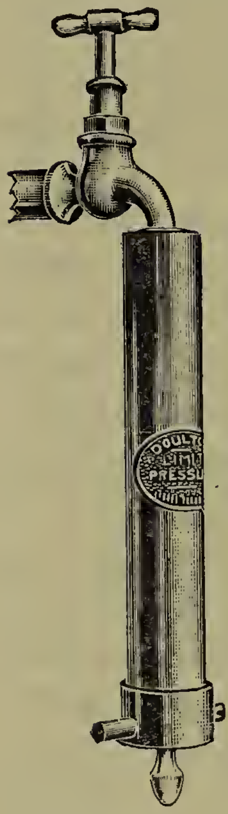

Fig. 24.
Doulton Filter.

Houston[1] in connection with rural water supplies to isolated dwellings describes a sand and gravel filter to be used as a domestic filter; it can be made at home. A most satisfactory kind of domestic filter depends upon the use of an earthenware cylinder; they give for a time a filtrate practically free from micro-organisms, and readily admit of being effectually sterilised. The Pasteur-Chamberland filter consists of a case of metal or glass, enclosing a cylinder of unglazed porous porcelain made of kaolin. The space between the outer case and the cylinder is capable of being placed in communication with an ordinary tap.

The Berkefeld filter is constructed on the same principle, but the filtering cylinder is made of infusorial earth. When compared, both this filter and the Doulton (Brown) porcelain filter gave 6 cc. per minute; the Doulton (White) porcelain gave 2 to 3 cc. per minute; the Pasteur Chamberland Filter 0·9 to 1·8 cc. per minute; the rate of filtration depends upon the size of the porcelain pore or grain of the material.[1]

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[1] "Rural Water Supplies," p. 107.

To ensure the highest rate of delivery the tubes must be regularly cleansed and sterilised; the Berkefeld candle, for example, should be held under a running tap and gently brushed with a piece of loofah or a clean brush which must not be too hard; no soap or other greasy matter should be allowed to come into contact with the candles.

After the preliminary cleansing the candle should be placed in a clean vessel with cold or tepid water, boiled for an hour, and allowed to cool down.

It is generally agreed that the Pasteur-Chamberland filter prevents the direct transmission of micro-organisms. Bullock and Crow showed that the Doulton (White) porcelain filter shared this property[2] and that the filtrates from highly contaminated waters are germ-free until sufficient time had been given for the bacteria to grow through the filtering mass. Further experiments showed that seven out of ten Doulton filters gave sterile filtrates for four days, the other three for longer periods; in the case of the Berkefeld filters and the Slack and Brownlow filter (? sand and porcelain) the organisms passed through within fifteen minutes of the commencement of filtration.[3]

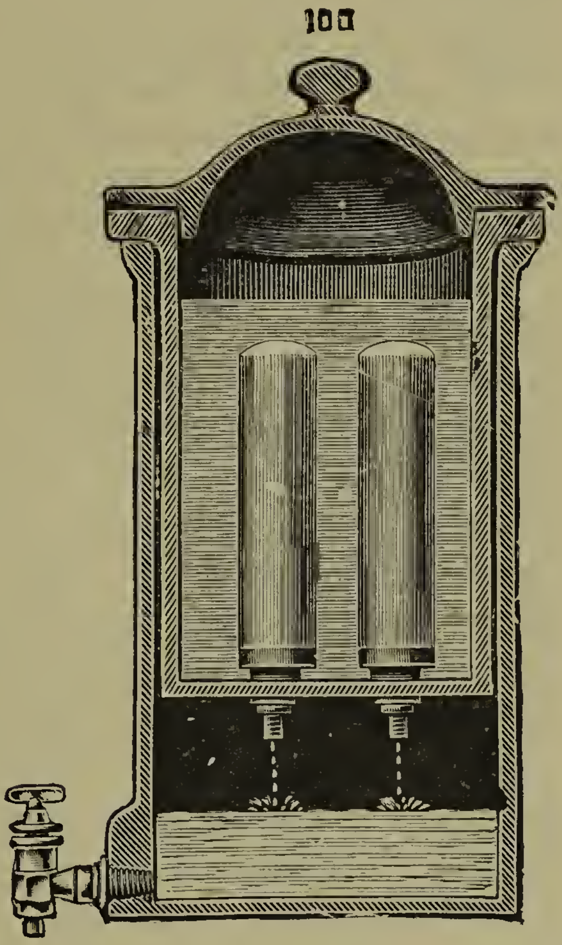

Fig. 25.—Stoneware Drip Filter with two Filtering Candles.

Impurities of Distribution—In addition to the impurities derived at its source water is liable to be contaminated in various ways in the course of distribution. In the case of river water as it nears the intakes the river should receive constant care as regards prevention of pollution although the provision of adequate storage enormously diminishes the risk of disaster following upon any accidental specific pollution of the river even just above the intakes.

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[1] "Journal of Hygiene," p. 149, July, 1906.

[2] *Loc. cit.*

[3] "Journal of Hygiene," January, 1908.

Storage reservoirs should be protected from the inroads and deposits of trippers, picnic parties and the public generally; fishing should as a rule be prohibited. The edges should be well above the ground level to prevent heavy rain washing in any objectionable matter.

It is urged that strictly speaking no workman who has ever had typhoid fever unless certified not to be a carrier should be actively engaged on waterworks; at least persons who have recently so suffered should be excluded. Obviously the same question arises in connection with workmen who have suffered from para-typhoid fever, dysentery or cholera. Convenient and adequate lavatory accommodation should be provided on all works and a watch kept on all employees, who should be duly warned by notices, etc., against committing any nuisance of this character.

The filter wells and the sand must be guarded from all sources of contamination as must be the pump wells, service reservoirs and distributing mains. The supply may be jeopardised when new mains are being laid down or old ones replaced.

In particular, the practice of laying water mains and sewers in proximity to one another is apt to render the water of a leaky main subject to contamination by sewage. Where the intermittent system of supply has been in force, foreign material has at times been sucked into water mains in which some defect existed, and has then been delivered with the water from taps. Under such circumstances sewage, coal gas, and other impurities have been found to issue from taps within houses. It was thought that with the introduction of the constant system of supply such evils would be altogether remedied, but experiments have shown that a water main, "running full," will suck up impurity from the surrounding ground, if a defect in the pipe gives opportunity for such an accident to occur; disease is therefore still liable to be transmitted by such insuction to the consumers of water, even when they enjoy the advantages of a "constant supply," though, under such circumstance, this source of danger is very materially lessened. This insuction is more likely to occur if the pressure varies or if there is a contraction of the pipe just beyond the defect; its occurrence can be proved by saturating the ground at the suspected spot with strong fluorescin solution and observing the water drawn from a suitable point beyond.

Defective hydrants are not infrequently a source of pollution.

The intermittent service entails of necessity storage of water in houses, and cisterns, unless they be constructed of suitable material such as slate or galvanised iron, be placed in a position in which they are not liable to receive added impurity, and be designed so that means of access of sewer air to them are precluded, are likely to themselves cause pollution of the contained water. Leaden cisterns may yield lead to the water, iron cisterns discolour it, and zinc is sometimes taken up by water. A cistern which contains water used for drinking purposes should never communicate directly with a water closet: in other words, a waste water preventer should always be provided.

Impurity has been transmitted to the mains where direct communication has existed (*see* p. 519). Again, sewer gas has obtained access to cisterns, owing to the overflow pipe being carried directly into a drain. The overflow pipe should, of course, be taken out into the open air, and made to serve as a "warning pipe." In any case a cistern should be placed in such a position that it is easily accessible for cleansing, which should be carried out at least once every six months.

The constant service has been largely substituted for the intermittent service in many large towns within recent years. With the former the house pipes are subjected to higher pressure, and more expensive fittings must be used; moreover, there is greater tendency with this service to waste of water, owing to negligence on the part of consumers who leave taps running; again, with the higher pressure there is greater likelihood of loss occurring from escape of water through leaky mains. By the use of Deacon's, or other forms of waste-water meters,[1] such defects in mains may be discovered and remedied; and if proper fittings are provided in houses, and a reasonable amount of care is exercised by the inhabitants, this waste can be to a very large extent controlled. No doubt in the past the waste from one or other cause has been excessive, and this has led in times of drought to failure of the constant service. When this has happened, in places where the use of cisterns has been discontinued upon the establishment of the constant service, serious inconvenience has resulted. In any case cisterns are required for the purpose of flushing water-closets and for supplying kitchen boilers, and there is advantage in possessing some means of storing water, in order that the household supply shall not wholly fail, at times when the water has to be cut off for the repair of mains, etc., or in consequence of the freezing of pipes, or other such exceptional occurrence. It has been suggested that to meet difficulties of this nature it is desirable to have a form of cistern consisting of an expansion of the service pipe, constructed in such a way as to exclude the possibility of the entrance of dirt and of accumulation of deposit from the water itself. Cisterns have been designed, moreover, provided with an arrangement which will admit of the removal from time to time of any deposit which may collect. In any case it is desirable that the ordinary domestic supply should be taken direct from the main, and that the cistern should only be brought into use if it is needed.

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[1] Water meters either register the number of times a cylinder of known capacity is filled, or alternatively the amount consumed is inferred from the velocity of flow registered by the meter. The auscultation of water pipes is of considerable use as a means of localising points at which leakage occurs, and the microphone has been employed with a like object.

Another important question which has to be considered in connection with the distribution of water is the possibility of symptoms of *lead poisoning* occurring from the use of lead pipes.

Lead is a cumulative poison; idiosyncrasy is especially marked with regard to this substance. The presence of $\frac{1}{100}$ grain of lead per gallon (0·336 milligram per litre) in the water supplying Yorkshire and Lancashire towns gave rise to marked and widespread lead poisoning.

When a town's water supply contains lead women and children are more liable to suffer than men; a larger number of miscarriages occur although most of the mothers do not show symptoms of lead poisoning nor even a blue line on the gums.

The ordinary symptoms of lead poisoning are well known; Oliver calls attention to atypical cases of plumbism caused by drinking water in which headache is the first symptom and to another set having as symptoms a gradual enfeeblement of the physical and mental powers, loss of weight, impaired locomotion, and a train of nervous symptoms, including sleeplessness, intense depression of spirits, forgetfulness, inability to apply oneself to mental work; the presence of lead in the urine reveals their origin.

Waters which contain a considerable amount of earthy salts, such as calcium carbonate, as a rule, act upon lead, but a protecting coat of carbonate, or of other salts of lead or of calcium or magnesium, is formed, which shields the lead from the solvent action of the water. Importance has been attached to the presence of silicates in water, as rendering it unlikely to actively dissolve the metal, an insoluble coating of lead silicate being formed. Pure, soft, and highly-oxygenated waters are, on the other hand, likely to dissolve lead; distilled rain-water, and more especially certain upland surface waters, have been found to possess this property in marked degree.

Thresh holds that no water acts upon lead unless both carbon dioxide and oxygen are present. Rain-water contains only a very little carbon dioxide. The soft upland surface water supplies of Glasgow and Manchester do not cause lead poisoning; the explanation offered is that a closely adherent and protective film of vegetable matter combined with oxide of lead or of insoluble oxy-carbonate of lead is formed.

It has been said that the presence of organic matter, nitrites, nitrates, and chlorides, favours the solvent action of water. The condition, however, which appears especially likely to exert this influence is that the water should contain free acid, and the upland surface waters derived from moorlands in Yorkshire and Lancashire, and supplying peaty waters to some of the towns in those counties, have been found in certain instances particularly active, especially during, or shortly after, periods of drought. Power and Houston ascribe the acidity of the water to the activity of certain bacteria; two non-motile non-liquefying organisms were isolated from peat by Houston which in suspension were capable of producing acidity and dissolving lead.

When acid waters must be used for public supplies, it is now becoming usual to pass them through sand rich in silicates and strewn with fragments of limestone or through beds of chalk or limestone to neutralise the acidity; to remove the plumbo-solvent action at least 4 parts per 100,000 of calcium or magnesium carbonate must be taken up by the water. Thresh advises the use of sodium silicate in preference to carbonates on the grounds that these "have very little effect upon the oxidation" and at the same time produce a more easily dissolved deposit which is carried forward into the taps supplying the dwelling. Soda has also been used for this purpose.

Another method is to use block-tin pipes, or to line the leaden pipes with tin, or to employ iron pipes; the two first-named kinds of pipes do not appear to afford security against solvent action, and block-tin pipes are very expensive. Iron pipes are satisfactory, so far as obviating risk of lead-poisoning is concerned, but they are apt to become blocked by rust.

HARD AND SOFT WATER

Owing to its power of dissolving many substances, water is never found pure in a state of nature. Water passing over the surface of the land takes up a certain amount of soluble material. However, as a rule the water percolating into the soil contains much more solid matter.

Two conditions must be present to make a ground water hard. The soil through which the water passes or some of it must contain the material producing the hardness and the conditions must be favourable for dissolving it, in other words, carbon dioxide must be present; upon this latter factor depends the great variation in hardness of different waters. Rain-water contains but little carbon dioxide; it is only after its passage through soil containing decaying organic matter that water acquires its hardness. A barren and sterile gathering ground collects a comparatively soft water.

The hardness of water is of great importance as determining its suitability for use in certain trade processes, and also in connection with waste of soap in washing. When soap is mixed with pure water a lather is readily obtained, but if the water contains lime, magnesia, etc., a certain amount of soap is disposed of, in forming oleates of these bases, before any lather is formed. Free carbon dioxide also unites with, and so uses up, some of the soap. Hard waters, therefore, cause great waste of soap.

The soap test used for determining the degree of hardness of a water represents the soap-destroying power; it does not afford accurate information of the amount and character of the calcium and magnesium salts present. The hardness of a water is often expressed in degrees, each degree is equivalent to the amount of soap destroyed by one part of calcium carbonate in one gallon of water (Clark's scale).

The standard of parts per 100,000 is being gradually adopted in this country. Waters with ·15 or more parts per 100,000 are considered hard; when 30 parts per 100,000 are present the water is objectionable for washing purposes. Any water with a temporary hardness below 4 parts per 100,000 should be examined to see if it has any action on lead, zinc or iron.

Soft waters are much more suitable for making tea, coffee, and meat extracts, and for various cooking processes, than hard waters.

If a hard water be boiled, a deposit is formed, and the hardness of the supernatant fluid is found to be diminished. The deposit usually consists, in the main, of carbonates which were held in solution in the water as bicarbonates and of calcium sulphate. Certain salts, principally sulphates, chlorides, and nitrates of calcium and magnesium, remain dissolved in the water, and to these its *permanent* hardness is due. The total hardness of the water is made up of the *temporary* or removable hardness, that removed by boiling, plus the *permanent* hardness. The deposition of salts from hard waters, on boiling, causes incrustation, or formation of "fur," on the surface of boilers, and this leads, of course, to loss of heat and may cause explosions, and thus militates seriously against the use of such waters.

Lewis maintains that hard (calcareous) drinking-water has no effect on health;[1] no evidence is forthcoming to show that any hard water has an effect on health, not even when the hardness is due in part to magnesium salts.

For the softening of hard waters numerous processes have been devised. *Clark's process* is sometimes applied on a large scale to public water supplies; it consists in adding lime to the water, in such quantity as to cause the calcium bicarbonate to be completely decomposed, forming calcium carbonate; the carbonates, being practically insoluble, are thus precipitated. Care must be taken not to add excess of lime above the amount required to combine with the carbon dioxide and thus convert the calcium bicarbonate into carbonate. The precipitate of carbonate of lime is either allowed to settle or, as in the *Porter-Clark process*, is removed by filtration through filter-presses.

Of recent years the Permutit system has come to the fore. Permutit is the name given to artificial zeolites, a rock mineral consisting of hydrated silicates of aluminium and alkalies; it has the power of exchanging the bases for other bases. This property can be used for the softening of water; analyses made before and after softening with Permutit show that all the calcium and magnesium salts are removed and salts of sodium (carbonate and sulphate) substituted. Thresh's experience of the use of hard waters in Essex after softening by Nature by passage through the Thanet sands, which contain the natural zeolites, shows that waters so softened although containing considerable quantities of sodium salts are perfectly wholesome.

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[1] See "Calcareous waters in health and disease," Proc. of the Royal Soc. of Medicine, July, 1911.

Clark's process is especially suitable for chalk waters; a mixture of lime and sodium carbonate is necessary for waters of a high permanent hardness.

It is often desirable to re-carbonate the water after softening; the addition of a small quantity of carbon dioxide removes any excess of lime which would subsequently have been converted into carbonates and deposited. Waters containing magnesium salts, especially the sulphates and chlorides, are difficult to treat.

For household supplies and manufactures requiring a very soft water, the Permutit system is the most suitable, the small amount of labour required making it the cheapest, but for town supplies the cost is far greater than that incurred in the use of lime and sodium carbonate.

WATER SUPPLY AND DISEASE

Intense thirst, muscular prostration, and loss of mental vigour, are produced in the entire absence of water for drinking purposes. These phenomena are of very rare occurrence in civilised communities, though they have been observed in this country within recent years, in cases, for example, in which men have been imprisoned in the earth as the result of mining accidents. The "water famines" of dry seasons, in English towns insufficiently supplied with water, sometimes cause, however, great inconvenience, and, apart from this, they may prejudicially influence health conditions by favouring accumulation of filth and interfering with the adequate cleansing of sewers. Lack of water implies, too, economy in its use for purposes of ablution, and in instances in which such economy has been strictly exercised, as, for example, where many persons have used the same bath, the spread of skin disease and ophthalmia appears to have been favoured. The diminution of the louse-borne diseases, *e.g.*, typhus, in recent years must be largely due to the larger share of attention devoted by civilised communities to personal cleanliness and the washing of clothes.

In 1849 Snow formed the opinion, as the result of inquiry which he made concerning outbreaks of cholera in London, that the disease was capable of being transmitted by water to which evacuations from cholera patients had obtained access. In 1854 an outbreak of cholera occurred in St. James, Westminster, which was traced to the use of water obtained from the famous Broad Street pump. This outbreak served to confirm the conclusions arrived at by Snow, and from that time onwards numerous other instances of the spread of cholera by water have been forthcoming. The facts demonstrated, in connection with cholera, no doubt stimulated inquiry with regard to the possibility of other forms of disease being transmitted by drinking water, and the belief that typhoid fever may be so conveyed was entertained, by Dr. William Budd and others, very soon after the distinction between that malady and typhus was finally established by Jenner in 1849–51. Suspicion was raised, moreover, by the extent to which typhoid fever had prevailed in Millbank Prison, an institution which, up to the year 1854, derived its water supply from the grossly polluted Thames. On a purer supply being procured, a remarkable diminution in the prevalence of the disease among the prisoners was observed. Recent experiences are dealt with later.

There are other maladies which may, with more or less certainty, be ascribed to a like cause. *Dyspepsia* and *diarrhœa* may undoubtedly be produced by drinking water in which there are impurities of certain kinds. Waters which contain iron occasionally cause dyspepsia, headache, and constipation. Again the fine particles of mineral matter sometimes suspended in water may mechanically exercise an irritant effect upon the alimentary mucous membrane, and so set up diarrhœa. If much organic matter, animal or vegetable, be present, a similar effect may be produced, and outbreaks of diarrhœa have been ascribed to water which has been exposed to contamination by sewer gas. There are many medicinal waters possessed of marked aperient action, particularly those which contain sulphur, and sulphate of magnesia or other mineral salts, and it is not surprising, therefore, that water which contains such materials in only small quantity, and which is not perhaps credited with the possession of any special aperient properties, should be occasionally associated with the production of diarrhœa. Waters rich in calcium and potassium nitrates have been found to produce similar effects, and the water from wells, sunk near graveyards, has been supposed to exert a like influence. In instances such as those last-named, excess of organic matter, or of nitrites and nitrates, may possibly be the cause of the symptoms produced.

Goitre is another disease which has been attributed to drinking water, and evidence has been adduced which shows that goitre often prevails among populations consuming water derived from certain limestone formations, and particularly from dolomitic rocks. On the other hand, in some localities provided with supplies derived from formations of the character specified, goitre does not occur. The question as to the precise relationship between goitre and drinking water still remains unsettled; the malady is supposed by many to be due to a deficiency in the iodine content of the food intake, either in the solid or liquid part of the food—probably the liquid.

Some of the *parasitic worms* are acquired from water contaminated with the infective stage, *e.g.*, the liver fluke of sheep occasionally occurs in man, the infective stage being found floating on water, or encysted on water-weed. The hookworm and the bilharzia worm can enter men in drinking water although they more frequently invade the body through the skin. Guineaworm disease is acquired, in India and West Africa, from drinking unfiltered water containing the minute water-fleas of the genus Cyclops which harbour the infective stage. *Tœnia solium* and *Tœnia mediocanellata* are probably usually introduced with food. *Tœnia echinococcus*, the round worm (*Ascaris lumbricoides*), and the thread worm (*Oxyuris vermicularis*) are probably occasionally distributed by water.

CHAPTER III

SOIL

THE surface and subsoil of a locality are formed, as a rule, by disintegration of the underlying rock. The surface soil, or mould, in addition contains considerable quantities of organic matter (humus), derived either from decaying vegetation, or from material of animal origin.

In many cases soil found at one place is removed from the place of origin by the action of water, ice (glaciers) and wind and deposited elsewhere as clayey, sandy or loamy soils often representing the mingling of material from several sources. Earthworms, by bringing portions of the soil to the surface in their castings, constantly turn over the upper layers of the mould. Burrowing animals, too, alter the character of the surface soil, and the superficial layers of earth abound with micro-organisms. Beneath the surface soil lies the subsoil, in which there is comparatively little organic matter, and in which the disintegration of the underlying rock has not proceeded to so marked an extent as in the surface soil.

The weathering of rocks is effected by the action of air and by the action of water with its dissolved gases, this action being greatly promoted by the splitting of the rock, which occurs when water freezes. Flowing water tends to wear away the surface of rocks ; and iceborne boulders have a similar effect ; the material carried away by water when deposited elsewhere, is termed alluvium ; " glacial drift " consists of the *débris* carried away by the action of ice.

The rocks of the earth's surface are classified as igneous, sedimentary, and metamorphic. The *igneous* rocks are derived from the cooling down of the molten matter of the once fluid globe ; they are divided into those which issue from the earth in a molten state as the product of volcanoes and include the basalts, pumice, lava, etc. —volcanic—and those gradually forced upwards and slowly cooled, granites, felsites (porphyries), etc.—plutonic. Both sets of rocks consist for the most part of quartz, felspar, hornblende, and mica. Their chief chemical constituent is silica—those which possess more than 60 per cent. of silica are called " acid rocks," and those with less than this amount, " basic rocks." Acid rocks are decomposed by " weathering " into clayey soils ; basic rocks possessing as they generally do appreciable amounts of earthy bases, iron or manganese, yield marls[1] and coloured clays.

The *sedimentary* rocks are formed by the deposition of fine particles from water or air, or are the result of the growth of plants or animals. They present evidence, as a rule, of having been precipitated at the bottom of lakes and seas in the form of distinct layers, and are hence sometimes called stratified.

Sedimentary rocks are divided into three classes according to their method of formation and each class is subdivided into minor groups :—

Mechanically formed by deposition and pressure from the broken down remains of other rocks.	Arenaceous.	Compact : Sand rocks or pebble rocks: include breccia (with coarse sharp fragments), conglomerate (with coarse smooth fragments) and sandstone (with fine particles united by a cement of calcareous or dolomitic nature). Greensands are sandstones stained with iron ; flagstones are sandstones split in big slabs, grit a rock made of angular grains of sand cemented by silica ; mudstones are composed of sand mixed with slag and being consolidated by pressure only are easily washed down into mud. Loose : Gravel or sand.
	Argillaceous.	Clay rocks. Clay when in massive form ; shale when laminated, slate (shale hardened by pressure).
Organically formed from skeletons and coverings of plants and animals.	Calcareous.	Limestone, chalk, oolite and marl.
	Ferruginous.	Ironstones (a limestone in which iron has replaced calcium).
	Siliceous (from radiolaria, sponges, diatoms).	Flints, cherts and infusorial earth.
	Carbonaceous.	Peat, lignite, coal.
Chemically formed by evaporation of aqueous solutions.	Carbonates.	Dolomites.
	Sulphates.	Gypsum, alabaster.
	Chlorides.	Rock-salt.

Rocks which have become greatly altered *in situ* by pressure are termed *metamorphic* rocks. Such are gneiss, which is really altered granite, and schists, slates, marbles, and quartzites.

The order in which the deposits were laid down is determined by the principle of superposition ; obviously the older deposits are beneath the more recent. Where this fails owing to changes brought about by movements of the earth the test of contained fragments

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[1] The term marl is usually applied to a clay containing 5–20 per cent. of calcium carbonate ; if the amount of calcium carbonate exceed 20 per cent., the soil is described as calcareous. Soils containing 10–40 per cent. of clay may be described as "sandy loams" ; if the amount of clay exceed this, as "loams" ; if it exceed 70 per cent. as "clay loams" ; and those with nearly 90 per cent. of clay are spoken of as "clay soils."

TABLE OF STRATIFIED ROCKS

Periods.		Systems.	Formations.	Life-Period	
Post-Pliocene.	Quaternary.	**Recent.**	Terrestrial, Alluvial, Estuarine, and Marine Beds of Historic, Iron, Bronze, and Neolithic Ages. Peat, Alluvium, Loess.	Range of Invertebrata and Plants in time Range of Fishes in time Range of Amphibia and Reptilia in time Range of Birds in time Range of Mammalia in time	Dominant type, Man.
		Pleistocene (250 ft.).	Valley Gravels, Brick-earths. Cave Deposits. Raised Beaches. Palæolithic Age. Boulder-clay and Gravels.		
Cainozoic.	Tertiary.	**Pliocene** (100 ft.).	Norfolk Forest-bed Series. Estuarine and Freshwater Lignite and clay. Norwich and Red Crags. Shelly Deposits locally called "Crags." Coralline Crag (Diestian). Remains of Polyzoa (formerly called Corallines) and Shells.		Dominant types, Birds and
		Miocene (125 ft.).	Œningen Beds Fresh-water, etc.		
		Eocene (2,600 ft.).	Fluvio-marine Series (Oligocene). Bagshot Sands. Pebble-beds, Sand, Loam, Clay. London Clay. Occur only in the London Basin. Woolwich and Reading Beds. Thanet Sands.		
Secondary or Mesozoic.		**Cretaceous** (7,000 ft.).	Maestricht Beds Chalk Included in these is the Upper Chalk (with Flints), Lower Chalk (without Flints), Grey Chalk, Chalk Marl. Upper Greensand. Gault.		Dominant type, Reptilia.
		Neocomian.	Lower Greensand. Green and Iron-stained Sands (contains Fuller's Earth). Wealden. Clays, Hastings Sands.		
		Jurassic (3,000 ft.).	Purbeck Beds. Limestone (Purbeck Marble), Clay. Portland Beds. Limestone, Oolitic Limestone (Roestone), Sandstone, Clay. Kimmeridge Clays (Solenhofen Beds), Shale. Corallian Beds. Limestone with Calcareous Grits (the remains of reef-building corals). Oxford Clay. Clay, Shale. Great Oolite Series. Clay, Limestone. Inferior Oolite Series (Lower Oolites). Oolitic Limestone, Sandstone Clay (Fuller's Earth). Lias. Dark Clay, Ironstone, Limestone (furnishes mortar which sets under water).		
		Triassic (3,000 ft.).	Rhaetic Beds. Keuper. Marl. Often contains Beds of Rock Salt, Gypsum and Alabaster. Muschelkalk. Absent in this country. Bunter (Mottled). Sandstone Ridges, Pebble-beds.		
Primary or Palæozoic.		**Permian or Dyas** (500 to 3,000 ft.).	Red Sandstone, Marl Magnesian Limestone, etc. Zechstein Breccia, Sandstone, Conglomerate. Dolomite. Red Sandstone and Conglomerate. Rothliegende.		Dominant type, Fishes.
		Carboniferous (Carbonaceous) (12,000 ft.).	Coal-measures. Sandstones (furnishes Ganister), Fire-clay, Ironstone, Limestone. Millstone Grit. Massive Grits, Conglomerates, Shales. Carboniferous Limestone and Culm. A pure Limestone.		
		Devonian and Old Red Sandstone (5,000 to 10,000 ft.)	Upper Old Red Sandstone Devonian Lower Old Red Sandstone Grits, Sandstones, Slates.		
		Silurian (Upper) (3,000 to 5,000 ft.).	Ludlow Series Wenlock Series Llandovery Series May Hill Series. Conglomerates, Sandstones, Mudstones, Shales and Limestones.		Dominant type, Invertebrata.
		Ordovician (5000 to 8,000 ft.). (Lower Silurian)	Bala and Caradoc Series Llandeilo Series Llanvirn Series Arenig and Skiddaw Series Limestones, Shales and Slates, Grits, Flagstones and Sandstones.		
		Cambrian (20,000 to 30,000 ft.)	Tremadoc Slates Lingula Flags Menevian Series Harlech Series Shales, Slates, Grits, Conglomerates, Sandstones and Flagstones.		
		Eozoic. Archæan (30,000 ft.).	Pebidian, Arvonian, and Dimetian. Huronian and Laurentian. Sandstone, Quartzite and Slate.		
		Pre-Cambrian.	Gneiss, Schists, Longmyndian Rocks. Contain no trace of past life.		

is applied ; "rocks which have been broken up in order to contribute pebbles and sand grains to a deposit must necessarily be older than the deposit which contains them as fragments" (Watts). Fossils also enable the age of strata to be ascertained when the order of super-position by reason of inversion of strata by folding, faulting or the occurrence of denudation is too difficult to be ascertained.

To some extent the depth of strata affords indication of the length of time which has elapsed during the process of their formation, but while great thickness of rock undoubtedly corresponds to vast periods of time, "it cannot safely be affirmed that a much less thickness, elsewhere, represents a correspondingly diminished period" (Geikie).

The table of stratified rocks on page 148 shows the approximate depth in feet of the several systems, and indicates the range in geological time of the various forms of life. The formations which lie superficially have been shown in distinctive colouring and lettering upon the inch sheets, and, in the case of some parts of the country, upon the six-inch sheets of the Geological Survey of Great Britain. In these maps faults are indicated by white lines, lodes by gold lines, the dip of strata is shown by arrows, and so on. Descriptive memoirs have been prepared to accompany many of the sheets.

Soil Features in Relation to Health—The soil influences health more through its physical properties than by its chemical constitution. The degree of permeability of the soil regulates its temperature and humidity, these in turn influence the temperature and humidity of the overlying atmosphere. Although the original heat of the earth's interior furnishes a constant source of heat that is of much importance and a slight amount of heat is produced by chemical changes in the soil, the radiant heat derived from

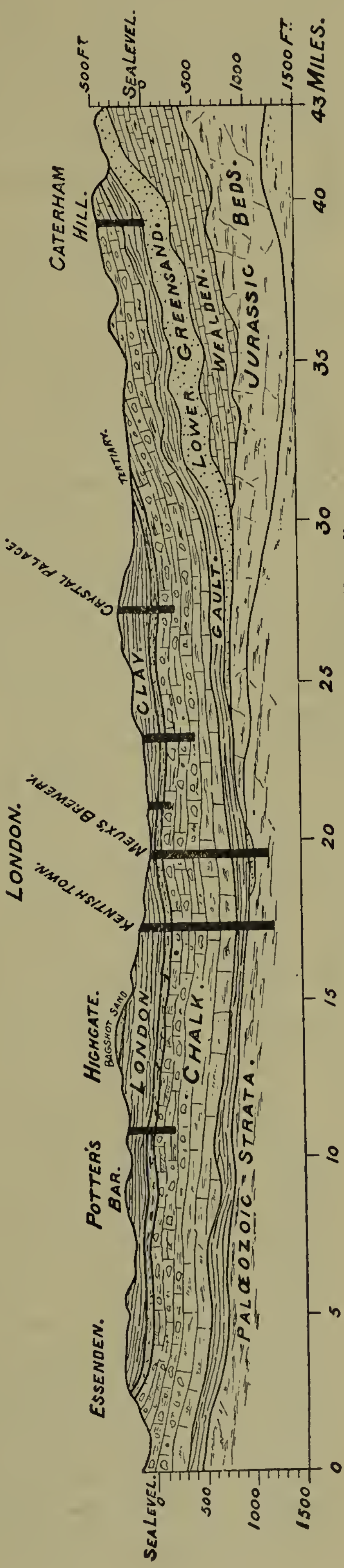

Fig. 26.—Geological section of London Basin with wells.

the sun is the principal source of the heat of the soil. Porous soils—the sands, gravels and chalks—hold much air between their particles, and air is one of the worst conductors of heat. The sun's heat is therefore unable to penetrate deeply, the surface is warm in the day and cool at night. The heat conductivity of impervious soils—the stiff clays, marls and slates—is much greater; the heat of the sun is rapidly passed on beneath the surface which remains cool during the day; at night such soils gradually part with their heat, warming the overlying air and causing a greater equability of atmospheric temperature.

The ability of soils to radiate heat depends on their colour, and upon the extent to which they are covered by vegetation. As a rule soils cool more quickly than they become heated. The temperature of the deeper layers of the soil does not respond to fluctuations in atmospheric temperature so speedily as the temperature of the surface soil; thus, it may be some days after the summer maximum of temperature is attained, before the temperature at 1 ft. below the surface reaches its maximum, and at a depth of 3 ft. the maximum will be still longer delayed.

The influence of daily changes of temperature is not appreciable in this country at depths exceeding about 4 ft., while at 40 ft. annual variations of temperature cease to produce any effect. Below this depth the temperature of the soil increases about 1° F. for every additional 50 ft. below the surface.

In estimating soil temperatures Lewis and Cunningham caused an excavation to be made to a depth of about 6 ft. A lining of brickwork and means of drainage were provided; two openings in the side of the brickwork, at 3 and 6 ft. below ground level, were made to communicate with wide tubes of perforated zinc running horizontally through the soil; into these tubes thermometers were inserted, the opening in the brickwork being closed with a cover and coated over with moist clay.

As regards humidity or its absence where there is a thick layer of pervious soil, allowing the rain-water to sink in deeply, the surface will dry rapidly and be free from fogs. If a shallow layer of pervious soil overlies an impervious stratum the ground water accumulates, rising nearly to the surface so that constant capillary attraction and subsequent surface evaporation keeps the place damp and liable to fogs. Impervious soils are by nature damp, rain lies on the surface in shallow puddles which slowly yield their moisture to the air or sinking in, possibly render waterlogged the few inches of soil on the surface. In this country, however, such waterlogged areas are not common; most of the land is cultivated and in consequence drained. Damp appears to conduce to rheumatism, neuralgia and diseases of the respiratory tract. Investigations seem to indicate that the general health of dwellers on damp soils is inferior to that of dwellers on drier soils.

The nature of the drinking water if derived from ground water in the immediate neighbourhood is dependent upon the soil surrounding the dwelling. Elevation is of importance in that it facilitates drainage, but this is more a matter of surface configuration.

Strata in Relation to Health—Districts in which the igneous rocks lie at the surface are usually hilly, the rainfall may be excessive, but the water for the most part runs away over the surface and does not percolate. It is from these areas especially that large upland surface water supplies are collected for the use of distant towns.

In localities where the clay slates prevail, water is often scarce. The mill-stone grit, belonging to the carboniferous formation, is hard and impermeable, and water readily runs away over it. In limestone districts the country is as a rule undulating and the water is hard ; in the case of magnesian limestone question has been raised as to the possible influence of the soil in favouring the prevalence of goitre. Sandstones and the chalk formation are permeable and healthy when free from mixture with clay and not underlaid with clay or gault clay. Sand when dry and pure makes a good building site except when it forms a shallow stratum overlying clay and the subsoil water is near the surface making the locality damp ; if there is much organic matter in the sand, the site is unsuitable. Gravel if of any depth is dry and healthy and is the best of all formations on which to build. Clay is unhealthy as it retains moisture and in consequence remains damp and cold.

In the London basin the Woolwich and Reading beds contain sands, gravels, and clays, and localities where they outcrop tend to show signs of dampness ; the Blackheath beds are of gravel, and places where they are exposed form excellent building sites. The London clay is, generally speaking, damp, and in very dry weather the soil cracks and fissures. If the surface be undulating, so that water can drain away readily, the disadvantages of London clay are minimised, and Symons held that " a house on a clay soil is not necessarily more open to objection than one on gravel." If the locality, however, be one in which London clay lies superficially in an area well nigh flat, or situated in a valley, so that water drains towards and not away from it, it is sure to be more or less damp.

High-lying river gravels and sands form as a rule excellent sites for habitations, and the Bagshot beds also possess this character. The valley gravels constitute for the most part the areas upon which Old London, and the villages surrounding it which are now absorbed into London, were built. In some instances, where these areas are low-lying, the level of the subsoil water is high, and the basements of houses are apt to show signs of dampness.

Alluvium, being low-lying, is generally damp and liable to flooding, there is usually difficulty in providing systems of sewerage for alluvial tracts, inasmuch as their low level is apt to entail inadequacy of fall in the sewers. Some alluvial tracts have been artificially raised and houses have been built upon the made-ground.

In parts of Old London the "made-ground" is of some thickness, having accumulated at the rate of 6 inches or more in a hundred years. The Bank of England rests on about 22 feet of made-ground. If such ground be of ancient origin, or if good material have been employed for artificially raising its level, there can be no objection to its use for building purposes; but in instances in which refuse has been tipped with a view to filling up excavations, or raising levels, the inhabitants are eminently liable to exposure to emanations from the impure soil. In recent years practices of the kind referred to have been to some extent controlled, bye-laws being in force in some localities, which require the removal of refuse material before ground can be used for building purposes; again, when the soil upon which a house is built is not natural virgin soil, it is usual to insist upon the surface being covered with concrete to a specified thickness. The effect of soil upon health can also be lessened by the construction of well-ventilated cellars and by drainage.

Ground Air—All soils contain air, and only the very densest rocks are free from it; loose sands may yield 50 per cent. of air. Pettenkofer showed that there was a much larger amount of carbonic acid in ground air than exists in the atmosphere, the quantity becoming greater at increasing depths, and being subject to annual and seasonal variations. Rainfall has especially marked effect upon the amount of carbon dioxide in ground air; an increase occurs after rain, the carbon dioxide being locked up in the deeper parts of the soil, the amount subsequently diminishes, owing to absorption of the gas by the water in the soil. The oxygen in ground air diminishes at increasing depths. The quantity of nitrogen is fairly constant, being about the same as that in the atmosphere.

Ground Water—If air and water exist together in a soil, the soil is said to be moist; when the point is reached, at which the interstices of the soil are entirely filled with water, the ground water level has been arrived at. This level of the ground, or subsoil, water may vary from only a few feet to many hundreds of feet from the surface. The ground water is in constant movement, ever flowing towards the nearest stream or towards the sea. Its level is liable to fluctuation, particularly in connection with rainfall. Pettenkofer attributed much importance to the measuring of variations in level of the ground water the necessary data for which may be ascertained by noting the levels of wells; he and others were led to the conclusion that variations in the level of the subsoil water have important influence in favouring the spread of certain diseases, particularly cholera and typhoid fever.

It is generally held that a persistently low level of the ground water, *e.g.*, 15 to 20 feet, is healthy and a persistently high level, *e.g.*, 3 to 5 feet, unhealthy. The foundations of a house should be at least 2 or 3 feet above the level of the ground water.

Adsorption by the Soil.—It is a matter of common experience that the soil has the property of taking up offensive odours ; the earth closet and the graveyard furnish ready examples. A less beneficial instance is in connection with the escape of coal-gas from leaking street mains ; the gas may be robbed of its odorous constituents by the soil to such an extent that, when drawn into the house with the soil air, its presence often escapes detection until the poisonous effects attract attention.

Micro-organisms in Soil—The bacteria in soil are almost wholly in the superficial layers ; below a depth of 12 feet they are relatively few in number except in soils with large pores or crevices into which bacteria have been washed down or in cases where they have been carried by burrowing animals or deposited by man in excreta.

Each sand or mineral particle is coated with a zoögleal envelope composed of bacteria. As bacteria require organic matter for their growth and multiplication they are far more numerous in rich garden soil than in ordinary sand and clays. For their development moisture and certain limits of temperature are also necessary ; dryness and extremes of heat and cold are unfavourable for their growth ; saturation with water may or may not be unfavourable, according to the variety of organism. Most of the bacteria in soil are saprophytes ; the micro-organisms pathogenic for man do not find conditions favourable for growth and development in the soil. For the most part the temperature is too low ; further they are crowded out by the overgrowth of saprophytes. Examinations have shown that the soil of graveyards contains no more bacteria than the corresponding soil in the same locality.

Losener's examinations in Berlin show that typhoid bacilli in buried bodies are usually destroyed within three weeks ; no typhoid bacilli were found on the outside of the body, in the coffin, in the earth or ground water even when this had penetrated into the coffin. After a few weeks cholera vibrios inside bodies died, tubercle bacilli in the body died at the latest within four months ; neither were ever discovered in the shroud, walls of the coffin, ground water or earth surrounding the coffin. Anthrax spores remained virulent at the end of a year's observation ; they were found on the surface of the bottom of the grave, evidently having been carried up by movements of the ground water.

The organisms present in soil are of much importance in the economy of nature, they dispose of animal and vegetable remains in contact with the soil and prepare them for absorption by the roots of plants. As soon as an animal or plant dies its protein constituents are at once attacked by putrefactive bacteria (aided by the larvæ of insects); these proteolytic micro-organisms growing in and upon the nitrogenous matter break it up into secondary and simpler products resembling those produced by gastric and pancreatic digestion; the complicated protein molecule is broken down by a series of hydrolyses into amino-compounds of simpler and simpler composition until the nitrogen is reduced to ammonia which combines with other substances present in the soil to form ammonium chloride and carbonate. This ammonium carbonate is rapidly oxidised by the nitrous or nitrite bacterium (called by its discoverer Winogradsky, nitromonas) into nitrites in which state, however, they remain only for a very short time, being converted by the nitric bacteria (nitrobacter) into nitrates. Ordinarily the nitrates are dissolved by the ground water and are either taken up by the roots of plants which build them up into new protein or pass in the ground water into the deeper layers of the soil and subsoil.

Very occasionally denitrification occurs, nitrates are reduced to nitrites, then to ammonia and further to gaseous nitrogen. Many organisms named and unnamed are capable of completely reducing nitrates. Denitrification does not occur in a well ventilated soil, for it requires lack of air, the presence of much decomposable organic matter and of nitrates—a combination rarely found in nature.

The carbon dioxide formed during the decomposition of organic material may pass off into the air as a gas, remain in the soil moisture in solution or be converted into carbonates.

The soil is capable of disposing of very large quantities of organic matter, but if it is overburdened it remains polluted and may endanger health, more especially by the contamination of drinking water. To prevent such pollution the manner of disposal of the polluting material is all-important. Purification takes place almost entirely in the upper layers of the soil, *i.e.*, those to which the bacteria are practically confined. When carcases are buried deeply or when sewage reaches the soil at a depth of several feet below the surface the process of purification is long delayed. A leaky cesspool or broken drain discharging its contents into the soil at a depth of 5 feet or so can seriously pollute the ground water, whereas the same material placed upon, or just beneath, the surface would be entirely broken up and all infection destroyed before it reached a depth of 5 feet. Many factors retard the purifying action of the soil; among these temperature, moisture and absence of oxygen predominate.

Soil and Disease—Formerly it was thought that the soil was responsible for many diseases but the whole trend of research has been to show that the number of infections associated directly with the ground are very few; the indirect influences are also thought to be much less than was formerly considered to be the case. A real danger is the pollution of soil with excreta, both human and animal.

Among pathogenic organisms the tetanus bacillus, the bacilli causing gas-gangrene, the anthrax bacillus, the botulinus bacillus and the eggs of certain parasitic worms have been demonstrated in soil. In the case of some other diseases, although the specific organism which causes the malady is either unknown or cannot be shown to exist under natural conditions in the soil, the existence of a relation between particular soil states and prevalence of the disease has been accepted by many. There are again certain other diseases which are suspected on less conclusive grounds to be associated with particular conditions of soil.

Tetanus is a disease which in natural conditions affects chiefly man and the horse. The disease is usually associated with a wound—especially a contused wound—received ordinarily from four to fourteen days previously and which has been defiled by earth or dung.

The tetanus bacillus is widely disseminated throughout the world as a common inhabitant of the soil, especially garden earth into which manure has been dug. Its normal habitat being the intestines of herbivora the organism is found in abundance in horse and cow manure. As cultivated soil is frequently turned over the organism is often found at the depth of several feet. The bacilli are abundant in regions where the temperature is high, as in the tropics where cases of puerperal tetanus and tetanus neonatorum (the infection taking place at the umbilicus) are very frequent.

In all probability the tetanus bacillus does not multiply in the soil; it does not find there the necessary anaerobic conditions, temperature and other factors necessary for multiplication.

Gas-gangrene is caused by pollution of wounds with bacteria derived from the soil. During the War examination of the discharges from wounds showed that gas-gangrene cannot be regarded as an ætiological entity but can be caused by a series of pathogenic anaerobes acting singly or in combination with each other or in association with certain well defined non-pathogenic anaerobes.[1] By degrees Pasteur's Vibrion septique (B. œdematis maligni of Koch) was disentangled from the mass of anaerobes; others frequently found were B. enteritidis sporogenes (B. welchii, B. aerogenes capsulatus), B. fallax, B. histolyticus, and another anaerobe, B. œdematiens. The most important of the anaerobes, the action of which may be ancillary to the condition of gas-gangrene, was B. sporogenes Metchnikoff.

Anthrax bacilli have been found in soil to which the discharges or blood of infected animals has had access, or in which the carcases of such animals have been buried; the spores may live in the soil and retain their virulence for years; cattle pastured on such infected land have acquired the disease after a very prolonged period. There is no case on record in which human anthrax has been contracted from contact with the soil. Pasteur suggested that the anthrax spores were brought to the surface by the agency of earth-worms, but this theory has been questioned on the ground that sporulation only occurs in the presence of oxygen. The risk of spread of the malady can be controlled to a large extent by burying deeply the carcases of animals dying of anthrax, and, particularly, by taking care to prevent blood and discharges from polluting the soil. It is important, therefore, that the infected carcase should not be opened before burial, and that no attempt should be made to utilise the hide or any other part of the animal.

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[1] Report on the Anaerobic Infection of Wounds, Medical Research Committee, Special Report Series, No. 39. 1919.

Hookworm Disease (ankylostomiasis) is largely spread by pollution of the soil resulting from faulty disposal of excreta. In Madras, for example, the number of public latrines supplied are very few and those provided are not sufficiently used. The larvæ find favourable conditions for development upon moist sand or loam; when the soil is dry or rocky the ova deposited in fæces rapidly dry and die out.

In New South Wales it has been observed that spread occurs only in areas of high rainfall; the bulk of the children infected are those who go barefoot.

Formerly severe anæmia was relatively common among Cornish miners; it was eradicated within a short time of the discovery that the hookworm was responsible and the carrying out of measures to prevent fæcal pollution of mines. Similarly many of the animal intestinal parasites of man are deposited on the soil and infect other human beings; in some cases they need to pass through an intermediate host. Protozoa and Nematoda (Roundworms) are mostly ingested directly; Trematoda (Flukes), Cestoda (Tapeworms) and Acanthocephala (Thornheaded worms) pass through an intermediate host.

In the case of Tænia solium, for instance, man pollutes the soil with fæces containing the eggs. Pigs devour this infection and return the disease to man. Soil pollution likewise results in the infection of cattle with the eggs of another tapeworm of man, Tænia saginata. Some of the parasitic protozoa have resistant stages in which they are capable of surviving in the soil for long periods of time. Ascaris lumbricoides and Trichuris trichura, worms commonly found in the human intestine, have very resistant thick-shelled eggs which have been kept alive for as long as five years; obviously soil once contaminated with these parasites can act as a source of infection for a considerable time. The eggs of these two worms are not infective at once after their extrusion from the alimentary canal but require several weeks or more according to the temperature and moisture to develop to the infective state.

Cholera—This disease shows such a remarkable tendency to originate time after time in particular localities that the possibility of some important relationship existing between it and states of soil has been a frequent subject of investigation. Pettenkofer, of Munich, was led to the conclusion that for cholera prevalence a pervious soil, and one in which the level of the subsoil water undergoes considerable fluctuations, is an absolute necessity. He held that the specific germ must be present in the soil, but thought it could only cause outbreaks of cholera under certain favouring conditions, and particularly when the ground water begins to fall, after having risen to a higher level than usual. A third factor, the importance of which he emphasised, is individual predisposition, and the co-existence of all three factors, x, y, and z, as he termed them, was, he held, necessary before cholera could occur. Cholera prevalences in Europe in 1892 and 1893 established beyond all question the fact that the malady is frequently transmitted by water, and thus did much to strengthen Koch's contention that the cholera vibrio was the cause of the disease, and that water containing it must be regarded as possessing infective properties; the soil theory, on the other hand, fell into some disfavour.

Another blow was the experimental finding of several observers that the cholera vibrio dies quickly when deposited on or in the soil under natural conditions. Houston has tested the organism *in rure* by sowing it in natural soil and exposing it "to conditions seasonal, meteorological, and other, such as would be likely to be encountered by Koch's vibrio, were it to become in the course of a cholera outbreak self-sown, as it were, in the soil, garden or other, of town or country." Houston tested in like manner the bacillus prodigiosus; this organism was recoverable from the soil after months, "whereas the exotic Koch's vibrio, though repeatedly sown in large numbers over several square feet of surface, could with difficulty be recovered from the soil after the lapse of a few days."

A reprieve was given to the soil theory by the suggestion "of a tendency in Koch's vibrio under adverse cultural conditions to undergo morphological modification to an extent rendering it extremely difficult of identification." The persistence in particular localities has on the other hand been held to be due to the presence of healthy carriers as well as of actual cases of the disease.

Typhoid Fever—The observations of Pettenkofer, with regard to the relation between height of groundwater and outbreaks of cholera, led to similar inquiries being made concerning typhoid fever. Buhl, from examination of records relating to the Munich wells, concluded that prevalence of typhoid fever occurs when the ground-water level is low, and particularly when, after rising to an unusual height, it has rapidly fallen. Although Pettenkofer also found that typhoid fever was more likely to occur at Munich, Berlin and Leipzig when the ground water was at its lowest, this does not hold in other countries and the relation is probably no more than a coincidence. Buchanan suggested that, even when typhoid fever is found to spread soon after a rapid fall following upon a sudden rise of the ground water, it is possible that the prevalence is due to the falling water being the means of conveying impurity into wells and so causing contamination of drinking water.

The continued presence of typhoid fever in large towns which have obtained pure supplies of water, and the fact that the disease shows a tendency to specially affect the same localities year after year, has, however, led to a number of observations being made with a view to determining what are the conditions, if there be any, which lead to soil states playing a part in connection with prevalence of typhoid fever. Certain registration districts in Durham (including those in which the outbreak investigated by Barry in 1890 and 1891 occurred) have shown, for a number of years, excessive mortality from typhoid fever; again, the death-rate in Dublin, from this disease, has for many years been high, and this fact has been attributed to saturation of the soil with the specific organisms which cause the disease. Cameron has pointed out that the number of cases of typhoid fever among inhabitants of Dublin living on gravel soil is considerably higher than among those living on stiff clay, and he suggested, as a possible explanation, the greater likelihood of germs being carried into the air in the case of the porous soil than in that of the stiff clay soil.

The ability of the typhoid fever organism to develop in soil has been made the subject of study by Sidney Martin for the Local Government Board. Dealing first with sterilised soils, he found that such soils, if they contained a large amount of organic matter, afforded a medium in which the bacillus retained vitality for periods of many months. In "virgin soils," similarly dealt with, no sign of vitality could be discovered after a few weeks. When, however, the vitality of the bacillus was tested in unsterilised soils, it was found that it at once died out; this fact being apparently due to its inability to compete with the bacteria natural to soil. Robertson, however, found that *Bacillus typhosus* could persist for long periods in certain soils, and that it could grow to the surface when planted to a depth of 18 inches. Later, confirmatory experimental results were forthcoming.

Firth and Horrocks (1902) found the bacilli to survive in some instances up to 74 days, Lorrain Smith (1903) up to 21 days, the average being 15 days, Savage (1904) in polluted river mud treated twice weekly with fresh sea-water, up to 5 weeks in one case and fairly readily up to 2 weeks and Muir (1908) in large numbers for about 20 days and still present after 70 to 80 days. Although these results show considerable differences they indicate that the typhoid bacillus can exist long enough in soil to be a considerable serious source of danger. Typhoid fever arising in camps and rural districts with conservancy systems may be due directly or indirectly to soil pollution; it is possible that the clouds of dust raised by the wind may include infected flies. Typhoid bacilli are said to have been found in the leaves and stems of vegetables grown on infected soil.

Diarrhœa—The cause of the very fatal malady (of which diarrhœa is the most prominent symptom) which especially affects children under one year of age, and more particularly prevails in the late summer and autumn, has been held to be intimately associated with certain states of soil. This soil theory of diarrhœa was examined in great detail by Ballard. He showed that the mortality from the disease is greater, generally speaking, upon porous soils than upon hard, impervious soils. He particularly insisted upon the influence exerted by fouling of the soil with organic matter—for example, in cases in which dwellings are erected upon made ground; in localities in which the midden-privy system of disposing of excreta contributes to soil pollution; and again in places in which a somewhat similar condition of things is brought about by leaky cesspools or defective drains. As regards moisture, Ballard found that extreme dampness or dryness was not so favourable as the intermediate condition in which the soil, while damp, permitted air to circulate through its surface layers. The question of temperature he regarded as especially important; he found that the summer rise of diarrhœal mortality did not commence in any particular year until the mean temperature recorded by a "four-foot" earth thermometer had reached about 56° F.

Much doubt has of late years been expressed as to whether any significance should be attached to the observed relation between diarrhœal mortality and earth temperatures at different depths. A certain number of days, it is urged, are required for incubation of the disease and for its gradual development to a fatal termination; again, time must necessarily elapse before the death can be registered. It may be argued, therefore, that the period of maximum mortality might be expected (on the assumption that high atmospheric temperatures favour diarrhœa) to lag behind that at which the highest atmospheric temperature is recorded. In fact, the date of maximum recorded mortality should, in view of the facts stated, stand in closer relation with the time at which maximum temperatures at some little depth below the surface are observed, than with that at which the maximum atmospheric temperature occurs. (See also p. 408.) Even if the earth temperature hypothesis be regarded as altogether unconvincing, however, the other reasons already mentioned for associating diarrhœa with soil-states still remain. Newsholme pointed out that incidence of diarrhœa follows that of rainfall more closely than it does the mean temperature of the air. He concludes that the soil is an important factor in diarrhœa, but that by provision of impervious paving in streets and yards, and of impervious flooring in houses, and by flushing, cleansing operations, etc., the influence of this factor can be materially lessened.

The provisional hypothesis formulated by Ballard was to the effect that the essential cause of diarrhœa resides ordinarily in the superficial layers of the earth, and is intimately associated with a micro-organism as yet unisolated. The vital manifestations of this organism are dependent on season and on the presence of dead organic matter; on occasion it "is capable of getting abroad from its primary habitat, the earth, and becoming air borne," thus obtaining access to food, etc. From food and from the organic matter of particular soils the organism can manufacture a virulent chemical poison, and, according to Ballard, "this chemical substance is in the human body the material cause of diarrhœa." These observations of Ballard have favoured the development of the fly hypothesis of causation of diarrhœa.

Dysentery is another disease which has been supposed to bear special relation to states of soil. The dysentery bacillus has been known to survive all winter in damp earth. The endemic areas[1] of dysentery are said to be characterised, as a rule, by possessing a damp, porous soil in association with a heavy rainfall and a high level of the subsoil water. It is probable that contamination of food materials with soil is responsible for some at any rate of the cases of botulism. B. botulinus (clostridium botulinum) has been found both in virgin and cultivated soil taken from North America, Europe, China and other countries.

Phthisis—More than fifty years ago Buchanan in this country, and Bowditch in the United States, were independently led to the conclusion that phthisis mortality was greater upon retentive than upon permeable soils. The observations of Bowditch were made in Massachusetts; the subject was forced upon Buchanan's attention, in the first instance, as the result of an inquiry made by him in 1865–66, concerning the "results hitherto gained by works and regulations designed to promote the public health." The works carried out, the effect of which it was Buchanan's intention to study, were, in the main, works of improvement of drainage, water supply, and scavenging, and with these had to be considered efforts made to amend lodging accommodation, and to cope with overcrowding.

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[1] Schmidt, "Centralb. f. Bakteriol. Abt. Orig.," Jena, 1902, xxxi, 522.

He selected as the field of his inquiry twenty-five towns with a total population of 600,000 persons, these towns being chosen, not because of any observed improvement in their mortality statistics, but as being places in which works of sanitary improvement had been most thoroughly done and had been longest in operation. It was found to be quite clear, after making due allowance for sources of error, that in these twenty-five towns the general death-rate from all causes had, with but few exceptions, notably diminished.

The most noteworthy and altogether unexpected result was, however, that obtained in the case of "consumption." In certain of the towns the reduction of deaths from this cause was great, and, on study of the facts observed, Buchanan was led to conclude that the sanitary improvement which "coincided with decrease of phthisis in town after town with least frequent exception," was "drying of the ground on which the town stands." Buchanan set out the facts for each of twenty-four of the towns in tabular form. At the head of his list stood Salisbury and Ely, towns in which there had been "much drying" of the subsoil, with a diminution of 50 per cent. in their phthisis death-rates; at the foot stood Alnwick with no drying of its subsoil and with an actual increase of 20 per cent. in its phthisis death-rate.[1] The correspondence between the extent of drying of subsoil and the amount of reduction of phthisis mortality was exhibited with remarkable exactness in most of the twenty-four towns, though in Carlisle and Chelmsford it was noted that ground water had been removed to a greater extent than in other towns which stood better as regards reduction of phthisis mortality; while, on the other hand, in Worthing and Rugby, there had been greater reduction in phthisis mortality than in other towns where the removal of subsoil water had been more complete.

The results of this inquiry were seen to be of such importance that it was decided Dr. Buchanan should pursue the matter further, and make careful study of the relation of soil dampness to phthisis mortality. It was felt that it would not be sufficient, in distinguishing between permeable and retentive soils, to rely merely on the broad divisions of the geologist, but that surface peculiarities must be taken into account. The work of surveying these surface peculiarities had just been completed, so far as Kent, Surrey, and Sussex were concerned, and by a fortunate chance, there was no other part of the country in which "varieties of soil would be greater, and differences of other sorts less obtrusive."

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[1] In Salisbury special arrangements for drying the subsoil had been made. At Penrith and Alnwick the deep drainage consisted of impervious pipes laid down in compact channels, so that no extensive drainage of water could occur either through or alongside them.

The fifty-eight registration districts in these three counties were brought under examination, in the first instance, with respect to their phthisis mortality, and secondly, as regards "the numbers of population in each district living upon various kinds of soil, under various topographical conditions." In considering the statistics of phthisis mortality the ages 15–55 were selected for examination, as being those which might be expected to furnish the most trustworthy results, and the mean death-rate of the two sexes was primarily relied upon. Many disturbing influences had to be taken into account, such as varying rates of increase of population, confusion between consumption and other diseases of the lungs, the effect of hospitals and public institutions, the use of particular places as resorts for consumptive invalids, and "the special circumstances of large bodies of the male population, particularly in camps and dockyards." Again, with regard to varieties of soil, the distribution of population on the different formations, in the counties selected as the field of inquiry, had to be considered.

With a view to summarising the facts, a grouping of soils into "pervious" and "retentive" was made, and the registration districts were classified according to the greater or less extent of mortality from phthisis observed in them. The following table was thus obtained :—

	Groups of Districts.	On Pervious Soils.	On Retentive Soils.
A	With least phthisis	909	91
B	Next least phthisis	877	123
C	Middle as to phthisis	795	205
D	With still more phthisis . . .	792	208
E	With most phthisis	642	358

The results were further analysed by selecting from the fifty-eight districts "such as were comparable with one another in regard to their position and geological structure," and then noting how their phthisis was affected "by the perviousness or imperviousness, elevation or lowness, slope or flatness" in the members of each more limited series (Tenth Report of the Medical Officer of the Privy Council).

The main conclusion drawn by Buchanan was that wetness of soil is a cause of phthisis to the population living upon it.

Buchanan's conclusions were adversely criticised by Kelly in reports, for 1879 and 1887, on the combined sanitary district of West Sussex. His main contentions were, that the figures of later years, not available when the original inquiry was made, present certain contrasts with the earlier figures given by Buchanan; that generally speaking, the impervious soils are to the north of the South downs, and that the question of exposed situation thus exercises disturbing influence; that the phthisis death-rate continued to show marked decrease subsequent to the date of Buchanan's inquiry, although improvements tending to cause drying of subsoil were not being carried out; and finally that social changes are largely responsible for the diminution of the rate of mortality from phthisis. As regards the first of these criticisms, Kelly's figures show that in recent years the phthisis mortality of West Sussex populations, living on what he termed "retentive soils," does not markedly exceed that of West Sussex populations living on "pervious soils"; this fact, however, is not incompatible with the different teaching of the earlier figures, but rather shows that subsoil drainage has had its effect, and that the retentive soils have now been brought into a condition in which they compare not unfavourably with the pervious soils. The question of bleakness of situation doubtless exercises influence comparable to the influence of elevation, slope, etc., considered by Buchanan; this disturbing element cannot, however, be regarded as invalidating conclusions based on examination of an extensive area, and dealing in minute detail with differences observed in the various localities of that area. As regards the cessation of improvement works in towns, it has been pointed out that the large amount of agricultural drainage effected throughout the kingdom might be expected to have produced results, in rural districts, similar to those brought about by sewerage works in towns. Buchanan recognised the disturbing influence of visitors at health resorts and of the aggregation of males in camps and dockyards. It is now realised that the instances given represent only a small part of the effect of *migration*, which is really an important cause of variations in the phthisis rates, not merely of counties but even of countries as a whole.

As examples of diseases suspected to be associated with particular conditions of soil the following may be given. *Calculus* and *goitre* have already been alluded to, in connection with the subject of water, and need not therefore be further discussed. Again *cancer* has been said to especially prevail upon flooded, low-lying, clayey areas, but this conclusion is not established with any degree of certainty. *Diphtheria* has been held to be especially prevalent upon cold, damp soils. Adams of Maidstone has investigated the relation between diphtheria prevalence and fluctuations in the level of subsoil water. He concludes that as long as the soil is well washed in winter, when the subsoil level is high, and well aerated in summer, when the subsoil level is low, all goes well; but that disturbance of this natural sequence of events favours the spread of diphtheria.

In connection with these observations Newsholme's conclusions with regard to the relation between rainfall and diphtheria may be referred to. Briefly stated, his inquiries lead him to believe that diphtheria only becomes epidemic "in years in which the rainfall is deficient, and the epidemics are on the largest scale when three or four years of deficient rainfall immediately follow each other." Longstaff showed, some years ago, that increase in the death-rates from scarlet fever, erysipelas, puerperal fever, and rheumatism, occurred in years of deficient rainfall. Newsholme suggests that the organisms of diphtheria and of the other diseases mentioned, are capable of living in a saprophytic stage of existence in soil. Such an hypothesis, he observes, "may appear to give undue importance to climatic conditions, as contrasted with personal infection." He therefore points out that "there is no reasonable doubt that personal infection is the chief means" by which diphtheria is spread, but he argues that something more than personal infection is required to explain why diphtheria spreads more in some years than in others, and he concludes that among "the external cultural conditions leading to increased virulence of the diphtheria bacillus, and its greater readiness for assuming a parasitic life, exceptional deficiency of rainfall and consequent exceptional deficiency of moisture in, and exceptional warmth of, the subsoil form an essential part."

Certain *rheumatic affections* are associated with exposure to cold and damp, and are therefore likely to prevail in localities with damp soils. Chronic rheumatism is usually said to be especially prevalent in damp and exposed situations. The term rheumatism, however, is very loosely applied, and the relation of the forms of disease in question to soil states has not been precisely studied. Acute rheumatism, as Longstaff showed, appears to be intimately associated with conditions of subsoil, its prevalence notably increasing after a series of dry years.

Malaria has long been held to be associated with a marshy condition of soil. The rôle played by the mosquito in the dissemination of malaria points to the conclusion that local conditions are mainly operative by favouring the existence of the species of Anopheles which transmits the disease.

Plague, it has been thought, might be spread by contamination of the floor of huts occupied by Indian plague patients. But cowdung floors were found by the Advisory Committee on Plague in India to remain infective only for 48 hours, floors composed of a mixture of sand and lime allowed to set did not remain infective for longer than 24 hours. From unsterilised earth the plague bacillus has not been recovered after 96 hours.

CHAPTER IV

FOOD

THE materials used as food are generally classified as follows :—

1. *Organic.*—These include the nitrogenous (proteins and albuminoids), and the non-nitrogenous foods (carbohydrates, fats, and vegetable acids).

2. *Inorganic.*—These include mineral salts and water.

Proteins and Albuminoids—Proteins contain in 100 parts about 16 parts of nitrogen, 54 of carbon, 22 of oxygen, 7 of hydrogen, and 1 part of sulphur ; some contain phosphates in addition. Of all the food substances they alone are capable of acting both as tissue formers and as work and heat producers.

Albuminoids are substances resembling proteins in chemical composition ; they can, however, only act as work and heat producers.

Gelatin and, to a less degree, other albuminoids, chondrin and keratin, can be employed to spare the proteins in a diet, but their nutritive value is less, they cannot entirely take the place of the proteins ; gelatin, for instance, is an incomplete protein in that it does not contain tryptophane, one of the amino-acids.

Extractives [1] are broken-down proteins ; they enter largely into the composition of meat extracts, beef-tea, etc. They are the causes of the flavour of meat and the most powerful exciters of gastric secretion known, thus aiding the digestion of any food with which they may be taken. The chemical constitution of the protein molecule is very complex. Protein is converted by the gastric juice into syntonin, peptone, and albumose ; when acted upon by the pancreatic juice it yields peptone and peptides, while some of the peptone is further decomposed into amino-acids of which a complete protein contains some 17 or 18. The products of protein decomposition are absorbed mainly in the form of albumoses and peptones (which unlike other proteins are dialysable) and are built up into or serve for the repair of nitrogenous tissue elements : they may also undergo further decomposition, yield fat, and possibly also carbohydrates, and become a source of supply of energy. The final products of the oxidation of the material originally represented in protein are carbon dioxide, water, urea, and other nitrogenous bodies.

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[1] The popular impression that they contain the nutritive properties of meat in a concentrated form is quite a mistaken one.

Proteins are of animal or of vegetable origin. The animal proteins include *native albumens* (serum albumen and egg albumen), the globulins (myosin of muscle, serum globulin and the vitellin of the yolk of egg); *derived albumens* closely allied to which is the substance called casein; *insoluble proteins* (fibrin) *and albumoses and peptones.* Vegetable proteins include the globulins and albumoses of the cereals and leguminous plants, as well as legumin and gluten, which are allied to casein and the derived albumens. Animal protein is said to be, as a rule, more readily and rapidly digested than vegetable protein.

Vegetable protein cannot entirely replace animal protein, the proteins of seeds especially lack some of the amino-acids—lysin, cystin, tryptophane and tyrosin—essential for nutrition; these are said to be "proteins of poor biological quality." The maize proteins for instance lack tryptophane and lysin. If the protein contain these amino-acids in too small amount there is a danger of the body being protein-starved. The proteins of cereals, especially wheat, are "poor in quality" in that the proportions of their several constituent amino-acids varies very markedly from that of the body tissues.

When proteins are consumed in considerable excess, nitrogenous waste products accumulate in the blood, and the excretory organs are apt to prove unequal to the task of removing these substances with sufficient rapidity from the body. Digestive disturbance results, and in some instances the development of gout and kidney disease appears to be favoured by such faulty dieting. Excess of protein tends to cause oxidation of fat, while carbohydrate appears to lessen the oxidation of both protein and fat. Thus, in Banting's treatment for obesity, the amount of meat is increased, while the quantity of starchy food is as far as possible reduced.

Fats are compounds of glycerine and fatty acids (palmitic, stearic, and oleic acids). The amount of oxygen contained in them is less than that required to enter into combination with their hydrogen so as to form water. Their main function is to serve as sources for the development of energy and heat, and they are usually found in considerable proportion in the diet of persons who live in very cold countries.

As we have seen, fats and carbohydrates are to a great extent interchangeable; a certain amount of fat is necessary, especially in infants and young children. Carbohydrates cannot entirely replace fats which are more easily stored in the body and give more staying power than carbohydrates. More important still, fats are very concentrated foods unlike carbohydrates which contain much water as well as cellulose and are apt to make the food too bulky. Lastly fats are a valuable source of vitamins and are very useful in cooking.

Carbohydrates, on the other hand, while consisting, like the fats or hydrocarbons, of carbon, hydrogen, and oxygen, contain the two latter elements in the exact proportions necessary to form water. They consist of three groups: the *glucose* group $(C_6H_{12}O_6)$ (glucose, lævulose, and inosite); the *cane sugar* group $(C_{12}H_{22}O_{11})_n$ (milk sugar, cane sugar and maltose), and the starch group $(C_6H_{10}O_5)_n$ (glycogen, dextrine, starch, and cellulose). Cellulose is not capable of being digested, and is discharged from the body unchanged. The carbohydrates act as work and heat producers.

The extent to which fats and carbohydrates are capable of replacing one another in a diet is not precisely known. Carbohydrates are converted in part, under certain circumstances, into fat. In the process of fattening pigs and other animals it is found that more adipose tissue accumulates than the fat contained in the food would account for. This excess of fat may be to some extent due to decomposition of protein, but it is probably mainly derived from carbohydrates.

The Vegetable Acids, of which the most important are tartaric acid and citric acids, have an important function, inasmuch as their salts are converted into carbonates, which, being absorbed, maintain the alkalinity of the blood and other fluids of the body. They are derived mainly from fresh fruits and certain vegetables. It may be that vegetable acids are in part derived from some form of carbohydrate food.

Among **Mineral Salts** the most important are chlorides and phosphates of sodium, potassium, and lime, and compounds of iron. Sodium chloride—common salt—enters into the composition of almost all foods. It is present, on the whole, in less quantity in foods of vegetable origin, hence the reason for its being used, for example, in bread making. Calcium phosphate is of special importance in connection with the formation of bone and is present in appreciable quantity in milk, the natural food of young animals. Iron is of importance, more particularly on account of its entering into the composition of hæmoglobin.

NUTRITIVE VALUE OF FOOD STUFFS

Theoretically the amount of energy obtainable from various foodstuffs, their "nutritive value," can be determined by calculating their efficiency as heat producers, *i.e.*, by estimating the amount of heat yielded by the complete combustion of a given weight of the substance.

The heat is measured in Calories—a Calorie being the amount of heat required to raise 1 kilogramme of water 1° Centigrade.

By experiment it has been found that during combustion—

1 gramme of protein gives off . .	4·1	available Calories.
1 gramme of carbohydrate gives off .	4·1	" "
1 gramme of fat gives off . . .	9·3	" "

These figures allow for the fact that protein is not completely burnt in the body, and that the whole of the substances taken into the body are not absorbed.

To obtain the number of Calories yielded by 100 grammes of a food the percentage of protein or carbohydrate present must be multiplied by 4·1 and the percentage of fat by 9·3.

For example, the percentage composition of protein in milk is 2 per cent., carbohydrate 6 per cent.

The number of Calories yielded by 100 grammes of milk is calculated as follows :—

Protein	$2 \times 4{\cdot}1 = 8{\cdot}2$
Fat	$4 \times 9{\cdot}3 = 37{\cdot}2$
Carbohydrate	$6 \times 4{\cdot}1 = 24{\cdot}6$
	70·0

The total number of Calories that must be supplied daily in the food has been ascertained by the following methods :—

1. A man is placed in a specially constructed chamber, the amount of heat given out from his body in a given time is measured as well as the amount of work done ; this latter can be expressed in terms of Calories. From these two figures the number of Calories required during 24 hours can be calculated.

2. The freely chosen diet of a healthy, fully grown man and his excreta (urine, fæces, and carbon dioxide given off in respiration) are chemically analysed. If the amount of carbon and nitrogen in the food and excreta is the same and the body weight does not vary, the amount of food taken is sufficient.

The number of Calories yielded by this amount of food can be calculated.

By both methods it is found that the daily food of a man doing moderate work must supply 3,000–3,500 Calories.

The following tables give the quantities of each food principle under different conditions :—

Subsistence

	Ounces.	Grammes.	Heat Value in Calories.
Protein	2·0	57	233·8
Fats	0·5	14	130·2
Carbohydrate	12·0	300	1230
Salts.	0·5	14	—
Total water-free food.	15·0	385	1594

Ordinary Work

	Ounces.	Grammes.	Heat Value in Calories.
Protein	4·5	127	520·7
Fats	3·5	99	920·7
Carbohydrate	14·5	397	1627·7
Salts	0·5	28	—
Total water-free food	23·0	651	3069·1

Laborious Work

	Ounces.	Grammes.	Heat Value in Calories.
Protein	6·5	184	754·4
Fats	4·0	113	1150·9
Carbohydrate	17·0	462	1894·2
Salts	1·3	37	—
Total water-free food	28·8	796	3799·5

It will be noticed that in the table given above the quantity of food required varies with the amount of muscular work to be done. Mental work which involves an almost stationary position does not require extra food. Generally speaking, the amount of food required is in proportion to the weight of the body; muscle and tissue which is always being used, however, needs more food than fat and bone. A tall, thin man requires more food than a short stout one. This is due to (1) the greater surface of the former allowing of the loss of a greater amount of heat, (2) the fat of the fat man being less capable of forming heat than the muscle of the thin man. Women require about $\frac{4}{5}$ of the food of men, owing to their smaller body weight consisting of a larger proportion of fat and to their performing less muscular work.

Children require more food in proportion to their weight than a fully grown person, provision of material for growth being necessary; in addition owing to their proportionally larger surface, they lose more heat.

The amount of food required by children at various ages is as follows:—

A child	under	2	requires	0·3	the food of a man doing moderate work.
,,	of	3–5	,,	0·4	,, ,, ,, ,, ,,
,,	,,	6–9	,,	0·5	,, ,, ,, ,, ,,
,,	,,	10–13	,,	0·6	,, ,, ,, ,, ,,
A girl	,,	14–16	,,	0·7	,, ,, ,, ,, ,,
A boy	,,	14–16	,,	0·8	,, ,, ,, ,, ,,

(ATWATER AND WOODS.)

In old age less food is necessary on account of the diminished activity of the cells and of the body as a whole.

During cold weather as a rule more food is required, and especially articles containing fat.

In summer the quantity of meat eaten should be reduced, its place being taken by fish ; fats should be replaced by carbohydrates.

Some relation must be maintained between the ratio of protein and fats and carbohydrates. One hundred grams of protein is usually held to be necessary in each day's food, but evidence is forthcoming to show that adults leading sedentary lives do not consume as much as this and yet remain healthy.[1] Fats and carbohydrates are to some extent protein-sparers.

A common way of stating the case is that proteins being taken as 100, fats should be about 65, carbohydrates 315, and salts 23 ; or to adopt a much more rough and ready rule the nitrogen should bear to the carbon supplied the proportion of about 1 to 15. Again, it

In 100 parts.

Article of Diet.	Water.	Proteins.	Fats.	Carbo-hydrates.	Salts.	Cellulose.
Lean meats . . .	75	20	3·5	—	1·5	—
Fat pork	40	10	47·5	—	2·5	—
Bacon	15	9	73·0	—	3	—
White fish	78	17	3	—	2	—
Egg (deducting 10 per cent. for shell) . .	75	13	11	—	1	—
Cow's milk . . .	87·3	4	3·5	4·5	·7	—
Human milk . . .	87	2·5	4	6	·5	—
Cream	66	3	26	3	2	—
Butter	9	3	87	—	1	—
Cheese	38	30	27	—	5	—
Bread	36	7	1·5	54	1·5	—
Flour	12	12	2	72	1	1
Oatmeal	15	12·5	5·5	64	3	—
Potatoes	75	2	·2	21	1	·8
Pea flour (dry) . .	11	25	2	57·5	3	1·5
Rice	13	8	1	76	1	1

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[1] Bornstein ("Zeit. f. Physik. und Diët. Therapie," xvi, 1912, p. 24) is of opinion that from 70 to 80 grammes of protein daily are sufficient in a mixed diet, and 60 to 70 grammes on a meat-free diet.

is sometimes said that a diet for an average man doing a moderate amount of work should contain 300 grains of nitrogen and 4,500 grains of carbon. Tests of this sort may be usefully applied to a composite diet in order to ascertain that the several kinds of foodstuffs are represented in proper proportions.

The table in the previous page gives the approximate amounts of foodstuffs contained in some of the common articles of diet.[1]

Food Accessory Factors (*Vitamines*)

In using these criteria the need for change and variety must on no account be lost sight of. Variation in diet is generally secured by persons who can exercise choice in the matter, on their own initiative. They become tired of one sort of food and replace it by another, thus instinctively maintaining a correct balance of diet. In the case of institutions, however, in which fixed dietary scales are adopted for reasons of economy and because the system renders it easy to check the quantities of food supplied, there is no doubt that too little regard has been paid in the past to the desirability of framing these scales in such a way as to avoid a too rigid adherence to a fixed routine. The occurrence of scurvy in ship's crews first led to the direction of attention to the question of impairment of health under conditions in which food adequate in quality, but lacking in variety, was supplied.

Although for some years an insufficient supply of vegetable acids was thought to be the fault it was also suggested that possibly there were other substances which are essential for a healthy condition of the body and which are consumed, albeit only in small quantity and from time to time, when the food is sufficiently varied but which may by chance happen not to be comprised among the constituent ingredients of a fixed diet scale. It has long been recognised that no animal can live upon a mixture of pure protein, fat and carbohydrate, and even when the necessary inorganic material is carefully supplied the animal still cannot flourish. Hopkins says, " The animal body is adjusted to live either upon plant tissue or other animals, and these contain countless substances other than the proteins, carbohydrates and fats." The existence of three at least of such substances which have been named food accessory factors or vitamins, has been fairly well established although none has actually been isolated. The source of all vitamins is the vegetable kingdom, the presence in the animal body or animal products such as milk is consequent on the consumption of vegetable food or of some other animal which has derived the vitamin from vegetable food.

It is generally held that the two accessory factors " fat soluble A " and " water soluble B " are indispensable for growth and nutrition of the animal organism ; it is thought probable that in some species vitamin C is a third accessory indispensable as a component of a normal dietary for growth. A point to be emphasised is that the human body not only requires vitamins but must have a sufficiency of them. Food is usually prepared both by manufacturers and in the home before consumption, and if any preparation processes materially reduce the amount of vitamin the results may be nearly as prejudicial as if the substance were entirely destroyed.

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[1] For a more or less complete list, see " Analysis and energy values of foods," R. H. A. Plimmer, D.Sc. (H.M. Stationery Office).

The use of the term "vitamin A or fat-soluble A" should be restricted to denote the accessory food factor necessary to promote growth and prevent and cure xerophthalmia in rats upon a diet adequate in all other respects. The anti-rachitic vitamin which has a similar distribution to vitamin A is a fat-soluble vitamin especially concerned with the calcification of bone and may be a distinct substance.

The chief sources of the vitamin are the green leaves of plants and marine algæ and diatoms, butter, cod-liver oil, cod roe and yolk of eggs ; it is also present in the germ of wheat and in liver. The vitamin content of butter, cream and lard, mutton and beef fat, and milk varies with the diet, breed, and management of the animal from which these are derived. Such foods as white bread, muscle meat, potato and margarine are deficient in this vitamin. Fish, like mammals, probably derive the whole of their vitamin A either directly or indirectly from the vegetable kingdom. Vitamin A remains in the unsaponifiable residue when fat is hydrolysed in absence of air. The identity of water-soluble B vitamin and the anti-neuritic factor is now generally accepted. This vitamin possesses a high resistance to heat and desiccation, it is consequently found in dried pulse and dried eggs. Experimental results have proved the presence of some vitamin B in milk. The power to synthetise the substance is possessed generally by plants ; it is present in the seeds of cereals, the embryo especially, and to a less extent the aleuron layer under the husk of the seeds of pulse ; yeast constitutes one of the richest known sources. The steel milling of wheat to produce white flour, from which the germ and husk have been excluded, gives bread deficient in this vitamin.

Digestibility of Food

The time necessary for the digestion of different articles of food is very varied.

An ordinary glass of milk has entirely left the stomach about 2 hours after it is swallowed, whilst a pint of milk is disposed of in about 3½ hours.

Two eggs lightly boiled have left the stomach in 1¾ hours, hard boiled in 3 hours.

7 ozs. of white fish were digested in 2½ to 2¾ hours, while a similar quantity of beefsteak required 3¼ hours. Salt fish offered more resistance to the action of the stomach, 7 ozs. of salt herring requiring 4 hours for its digestion.

$3\frac{1}{2}$ ozs. of raw mutton is digested in precisely the same time as an equal weight of beef; veal required $2\frac{1}{2}$ hours for digestion as compared with 2 hours for beef; 3 ozs. of pork required 3 hours for the complete digestion as compared with 2 hours for beef. On account of the loose and delicate nature of the connective tissue the thymus gland (throat sweetbread) and pancreas (stomach sweetbread) are among the most digestible of animal foods, 9 ozs. of sweetbread being completely disposed of by a healthy stomach in $2\frac{3}{4}$ hours, while a similar weight of beefsteak requires at least $4\frac{1}{2}$ hours for its complete digestion.

Chalmers Watson gives the following order of digestibility of the various animal foods, the more digestible being placed first:—

Milk.
Soft-boiled eggs.
Sweetbread.
White fish (boiled).
Chicken (boiled).
Lean roast beef and beefsteak.
Egg, scrambled.
Mutton (roasted or boiled).
Bacon.
Roast fowl or chicken.
Tripe, liver.
Roast lamb.
Chops (mutton or lamb).
Corned beef.
Veal.
Ham.
Duck, rabbit.
Salmon, herring, mackerel.
Roast goose.
Lobsters and crabs.
Pork.
Smoked, dried or salted fish and meats in general.

As regards the duration of its stay in the stomach bread occupies a middle position among vegetable foods, $2\frac{1}{2}$ ozs., or an ordinary slice, have not completely left the stomach in 2 hours and 20 minutes, whilst $5\frac{3}{4}$ ozs., or two rather thick slices, remain about an hour longer.

The digestibility of roots and tubers depends largely on the amount of cellulose which each contains, but all of them are only indifferently absorbed and are prone, by reason of their bulk, to upset the working of the stomach and intestines if eaten in large quantities.

Cooking

Cooking develops certain flavours and so makes the food more appetising; it has also an important influence in favouring the destruction of parasitic forms of life (including pathogenic micro-organisms) which may be present in the food.

Cooking, however, diminishes the digestibility of animal food by causing toughening of the proteins. Most proteins coagulate at 170° F. If the temperature at which the meat is cooked is kept about this level, the shrinking and hardening of the proteins is rendered as small as possible.

Fats at high temperatures tend to split up into fatty acids which have an irritating effect on the lining of the stomach. Thus cold fat is more digestible than hot fat. Fat heated and allowed to cool again, as in dripping and bacon, assumes a granular form, and is more easily attacked by the digestive juices.

Animal foods generally lose weight on cooking, this loss being chiefly due to diminution in the percentage of water contained in the food. The average loss of weight in roasting meat is about one-third ; in the process of boiling the loss is only about one-fifth of the total bulk.

Boiling in the form of stewing is a favourite means of cooking among the poor, many of whom cannot afford to keep up the larger fires required for baking.

The object of stewing meat is to obtain a strong broth. For this purpose the meat should be cut up into small pieces, placed in cold water. In this way a larger surface of the meat is exposed to water at a temperature at which the proteins are dissolved, not coagulated. The prolonged action of the heat and moisture on the connective tissue converts a large proportion of it into the more easily digested gelatin. This method of cooking is the most economical.

To boil a piece of meat the joint should be plunged for a few minutes into boiling water, so as to seal up the surface by coagulating the proteins, thus preventing the escape of the soluble proteins into the water, of which as little as possible should be used. The further cooking should be carried out at a temperature just below 170° F.

In steaming, food is exposed to the action of steam produced by boiling water in a pot surrounding that containing the fluid. Fish should be cooked in this way, and not boiled lest the extractives present, already small, should be lost in the water used.

In roasting, heat is conveyed to the meat by direct radiation. A high temperature should be maintained at first, in order to seal the surface by coagulating the proteins. When this has been done, the remainder of the cooking should be carried out at a lower temperature.

When a thin piece of meat, such as steak or chop, is exposed to a high temperature, the protein throughout the whole thickness of the meat is at once coagulated.

In baking, the process is the same as in roasting.

Frying, as is usually carried out, is a form of roasting, the fat being used to prevent the food from sticking to the pan.

In frying proper, however, the food to be cooked is suddenly exposed to a very high temperature, usually by plunging it into nearly boiling oil (olive oil or refined cotton-seed oil is best if dripping cannot be used) for two to three minutes, when the coagulation of the proteins on the surface at once takes place, preventing the escape of soluble substances.

Vegetable foods are made much more digestible by cooking, especially by boiling. A temperature of about 180° F., is as effective as that of the boiling-point of water (212° F.). The cellulose framework is softened, allowing of the more easy penetration of the digestive juices. Starch grains swell and rupture their envelopes. Vegetable foods, as a rule, take up water and lose a certain amount of salts as a result of cooking.

DISEASES CONNECTED WITH FOOD

Overfeeding

A moderate excess of food, such as is entailed in an extra good dinner on Sunday, is probably beneficial. The habitual consumption of protein far in excess of the needs of the body may be one of the causes of arterio-sclerosis and its associated effects—apoplexy, heart and kidney disease.

Excess of carbohydrate or fats often causes obesity.

Underfeeding

Persons who are underfed are less resistant to cold and infectious diseases. An example of the lessened resistance to infection is seen in the large number of cases of tuberculosis occurring among ill-nourished persons.

Epidemic ophthalmia occurs especially among the underfed. The young are less able to withstand the effects of underfeeding than others. In India especially, famine dropsy occurs. The important contributions to the study of famine dropsy made by Cornish and Porter during the Indian famine of 1877–8 form the starting-point of the modern conception of the disease, which was almost rediscovered in the last War and named War Œdema. It is caused by prolonged underfeeding on a diet insufficient qualitatively and especially deficient in calorific value. The four cardinal symptoms are œdema, polyuria, bradycardia, and marked muscular weakness. The nervous symptoms of beri-beri are absent as are the skin lesions of pellagra and the spongy gums and tendency to bleed of scurvy. No striking abnormalities of metabolism occur; the changes of the urine are merely those consequent on a low diet, no albuminuria is present. A reduction in the red blood cells occurs and a tendency to leucopenia.

Scurvy

A severe form of scurvy, infantile scurvy, Barlow's disease, which occurs especially in hand-fed babies brought up on preserved foods, sets in mostly between the sixth and twelfth month of life. The milk of a woman whose diet consists chiefly of cooked, dried or preserved foods may not contain sufficient anti-scorbutic substance and her sucklings suffer from scurvy. All hand-fed children should be given orange or tomato juice or some other anti-scorbutic.

The classical history of the development of the conception of scurvy as due to the absence of some accessory food factor is recorded in the well-known report on accessory food factors.[1] The substances regarded as richest in this vitamin include raw fresh cabbage leaves, swede juice, sprouted new peas, grape fruit juice, lemon juice fresh and dried, naartje juice, orange juice fresh and dried, raw tomato and tomato juice (tinned). Milk is by no means rich in anti-scorbutic, the potency depending upon the diet of the cow. The anti-scorbutic value of the various brands of dried milk put on the market probably varies considerably, but perhaps milk dried by the spray process having greater opportunities for oxidation is less potent than that made by roller processes.

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[1] "Report on the present state of knowledge concerning accessory food factors (vitamins)," second edition. H.M. Stationery Office.

Vitamin C is readily destroyed by heat; it is very sensitive to oxidising agents, but fruit juice may be evaporated *in vacuo* without serious loss; the addition of either acid or alkali to the water in which vegetables are boiled appears to increase the loss of anti-scorbutic property. This vitamin is produced during the germination of seeds.

Rickets

Much difference of opinion exists as to the etiology of this disease. Cheadle in 1888 stated that rickets is a dietetic disease and that the chief defect in the diet is a want of animal fat. But children have been fed on a diet poor in fats without development of rickets, and other children after a fat rich dietary including cod-liver oil have developed severe rickets. The diet of the poor Indian native is very deficient in animal fat, yet rickets is a very rare disease in that country. It might be thought that the digestion and absorption of fat in rickets is imperfect, but the investigations which have been made go to show that these processes are as efficient in rickets as in health. More recent views are that the dietetic factors of primary importance are the amount and relative proportion in the food of calcium and phosphorus and the amount of the fat-soluble A vitamin and that other factors such as excessive carbohydrates play a contributory part.

Deficiency in the supply of calcium was for many years a favourite theory of causation, but rickets has been induced when a normal amount of calcium is supplied and many children develop the disease on a diet of cow's milk which contains at least four times as much calcium as does human milk. It may be remarked that a deficiency of calcium has been found in the blood in active rickets. The utilisation of the calcium supplied has been held to be defective in ricketty children; this would seem to be borne out by the few examinations made of the intake of calcium in the food and the output in the fæces in the case of both healthy and ricketty children when it was found that the retention of calcium in the body occasionally falls below the normal. Other writers suggest as the cause inability of the rachitic cartilage to fix the calcium or the calcium not being supplied in the proper combination—*e.g.*, through the defect of some other element such as phosphorus; a very definite deficiency of inorganic phosphorus in the blood has been detected.

In New York, Hess and his co-workers found that the calcium and phosphorus content of the blood followed the monthly height of the sun, and taking into account the maximum incidence of new cases of rickets in March and the absence of new cases in June and

July considered that the presence of these elements in the blood is controlled by sunlight and coincides inversely with the incidence of rickets.

The importance of an adequate supply of the fat-soluble A vitamin in the food is suggested by the animal experiments of Korenchevsky who produced rickets in young rats by feeding them on a diet deficient in this vitamin alone (but containing an ample supply of calcium and phosphorus), the deficiency must be commenced at a sufficiently early age, and the mothers not too well fed during pregnancy and lactation. If, however, they are given cod-liver oil or plenty of animal fat during these periods, sufficient stores of the anti-rachitic vitamins are accumulated by the offspring to carry them over the period of susceptibility to rickets.

This view receives the support of the English workers in Vienna where infants fed on milk with the addition of a small quantity of cod-liver oil (rich in fat-soluble A) were found not to develop rickets. On the other hand, Hess in New York has fed a series of children on a diet in which the fat was in the form of cotton-seed oil (containing but little fat-soluble A vitamin) and yet he saw no greater tendency for those children to develop rickets than those normally fed.

A rival theory is that some defect of personal hygiene, particularly insufficient air space, confinement and lack of exercise are responsible. Findlay in Glasgow made extensive inquiries as to the home conditions of families with and without ricketty children. The chief differences found were in air space and maternal care. The average air space per person was in the case of marked active rickets 396 cubic feet, in the case of slight rickets 452 cubic feet and in that of the non-ricketty child 565 cubic feet. So far as maternal care was concerned this could be described as good in only 46 per cent. of the ricketty as opposed to 84·5 per cent. of the non-ricketty households, explained to some extent by the ricketty families being larger and the mother's health not so good. Dirt did not seem to play an important part in the question; as regards diet, there was very little difference in the caloric value and the amount of protein or fat consumed in the two sets of families. Experiments on the effect of confinement of animals led him to the view that lack of muscular exercise has a potent influence in this connection; pups sent to the country and properly exercised remained well although fed on a diet with a small amount of fat while those kept in the laboratory showed signs of rickets in spite of their being given much more fat than the other dogs.

From these considerations he evolved a method of treatment by massage and electricity which he finds enables a ricketty child who has lost the power of walking to regain this power within the shortest space of time.

Hutchinson found at Nagik in India that early and late rickets occurred among the wealthy Hindus and Mohammedans who consume much animal fat in the form of cow's milk and ghee, but confine their children and daughters about puberty in airless and sunless rooms; the poor who lived in tents or huts and led an open-air life escaped: marked improvement occurred by simply putting the patients in the sun and fresh air.

Corry Mann, working in London, did not find any difference in the hygienic conditions of healthy and ricketty children; his experience was that of children living side by side, some become ricketty while others remain healthy. He found rickets among the later members of larger families and was led to ascribe the disease to the cheaper and less satisfactory food the parents were able, owing to strained means, to provide for the children. The results of the investigation led him to place fat deficiency with carbohydrate excess as the most important cause, the next being unsatisfactory breast feeding, the breast milk being poor or the breast feeding being continued too long. Of 120 ricketty children in Liverpool 80 had been breast-fed up to at least six months (60 of these for eight months to a year).

The possibility of an infective origin of rickets has long been considered. Koch considered that he could induce rickets experimentally by the injection of cultures of streptococci. The evidence as to infectivity is discussed in the Lister Institute collected papers 1922–3; in the present state of knowledge no clear proof of the importance of the part played by infectivity is forthcoming.

Recently attention has been directed to the influence of light, particularly sunshine and ultra-violet rays. Experiments on animals carried out by McCollum, Hess, Mellanby and others tend to show that exposure to actinic rays prevents the development of rickets on a diet which in control animals not exposed to these rays causes rickets.

The English workers in Vienna taking a radiographic standard of diagnosis found that infants fed on full milk with heavy carbohydrate additions developed rickets in winter, but not in summer. The most marked improvements in ricketty children occurred in infants treated out of doors; this was attributed to the action of the rays of short wave length which are easily absorbed by glass and are in consequence relatively few in any room lighted by glass windows.

Although very few deaths are certified as due to rickets, indirectly the disease with its varied manifestations is in all probability a very great cause of excessive morbidity. The disease has a marked effect on the survivors; children showing evidence of rickets (bone deformities) are on an average one or two years mentally backward as compared with other children.

It would seem that the establishment of infant welfare centres has lessened the incidence of rickets; it would be difficult to say whether this has been effected by attention to the early signs of digestive disorders including malnutrition and the prescription of appropriate diet or by encouraging mothers generally to exercise their children in the open air. In view of the occurrence of rickets in breast-fed children proper feeding of the mother during pregnancy and lactation are evidently of the highest importance.

It has been suggested (Dalyell and Chick, 1921) that the hunger osteo-malacia, "essentially of the same nature as rickets," which occurred among adults of the poorest class in Vienna in 1918–20, the post-war years of great food deprivation in that city, was possibly due to a specific deprivation of fat-soluble vitamins, accompanying a diet which was poor in quality and low in quantity.

Xerophthalmia (*keratomalacia*). In a varying percentage of rats suffering from vitamin A deficiency a swelling of the lids of one or both eyes occurs, followed by an inflamed condition of the conjunctivæ. (Xerosis of the cornea may be the first symptom observed in rats and is invariably the first change observable in guinea-pigs.) The discharge becomes hæmorrhagic and often purulent.

External eye disease in young children associated with a deficiency of fat in the dietary has been described in Denmark and Japan and named xerophthalmia.

The hemeralopia, or night blindness, which has been observed among older children and adults upon a defective diet, often in epidemic form, appears to be the analogue ætiologically of the xerophthalmia occurring in rats and in infants; xerosis of the conjunctiva may be present.

Beri-beri is considered by many to be a disease due to deficiency of vitamin B in the dietary; it has long been prevalent in China and south-east Asia. Its existence in numerous localities in the tropics has now been recognised; it is occasionally met with in temperate regions. In Japan the malady is still not uncommon, and it has been reported of late years in Australia, Fiji, the Sandwich Islands, and elsewhere, including even certain institutions, such as lunatic asylums, in England, Ireland and the United States. In Brazil and in the Malayan archipelago it is especially frequently met with.

In 1915 over 300 cases of beri-beri occurred among British soldiers in Mesopotamia.

Beri-beri is a form of multiple neuritis resulting in motor and sensory disturbances of the lower portions of the upper and lower extremities. In typical cases, owing to involvement of the vasomotor nerves, general dropsy occurs. Almost as important in diagnosis as the weakness of the legs, with anæsthetic and œdematous areas, and clumsiness of the hands owing to blunting of sensation, is the early palpitation of the heart upon the slightest exertion due to involvement of the vagus nerve, manifested by a tumultuous action of the heart and a weak pulse.

According as various features predominate, (i) wet or dropsical, (ii) dry or atrophic, (iii) paralytic, acute-pernicious, or fulminating types, with marked vagal and vaso-motor involvements, have been described. Rudimentary indefinite forms of the disease are common in the tropics. A diagnosis of nephritis is often made in the wet type, and locomotor ataxy in the dry type, when the possibility of the disease existing in an Oriental crew after a long voyage, has not been borne in mind.

It has long been recognised that the malady does not spread directly from patient to patient; it is now generally held to be due to the absence of the antineuritic vitamin in the diet. Numerous observations have been made showing the connection between beri-beri and the consumption of polished rice as a predominating article of diet.

In 1909 Fraser and Stanton carried out experiments in the feeding of Javanese coolies employed in building a road, far removed from any village which might introduce the possibility of infection being the cause of the disease.

The 493 coolies were divided into two parties each of which were quartered in virgin jungle, and completely isolated from each other. The 220 coolies of one party were fed on white rice (polished rice from which the pericarp, and most of the aleurone layer, and, more important still, the embryo had been removed by milling); in the party, 20 cases of beri-beri arose.

Not one case occurred in the party of 273 who lived on rice which had been parboiled; this process causes the husk to be more readily detached, and the pericarp to adhere more firmly to the grain so that, when milled, less of the anti-neuritic vitamin present in the outer layers is lost. Substitution of parboiled rice for white rice, in the feeding of the first party, brought about a cessation of the outbreak.

The contact of persons on a parboiled rice diet with the beri-beri cases, caused no spread of the disease. An important feature observed was, that as long a period as 87 days occurred, before the disease appeared among the party on the polished rice diet.

From the relatively small numbers of those affected when large bodies of persons are placed under conditions liable to produce the disease, it is obvious that predisposing conditions are of much importance. These factors are held to include debilitating conditions such as unhygienic quarters, excessive grief, over-exertion producing fatigue, as well as digestive derangements and such conditions as malaria, ankylostomiasis, etc.

Rice plays an unimportant part in the dietary of Brazilian cases of beri-beri; the British cases in Mesopotamia ate white biscuits, tinned meats, and horseflesh. From numerous other reports of the disease in persons who did not eat rice, it is obvious that any predominating carbohydrate article of diet deficient in the neuritis-preventing substance can produce beri-beri.

Eijkman and others have shown that the occurrence of polyneuritis gallinarum was prevented by the addition of rice polishings to the diet of fowls fed on neuritis-producing rice. A diet of sago, boiled potatoes, corn grits or macaroni is equally capable of producing polyneuritis in fowls.

It has been observed that if a rice contain less than 0·4 per cent. of phosphorous pentoxide it is liable to produce beri-beri; the anti-neuritic substances in rice polishings possibly serve as an activator in the metabolism of phosphorus.

The etiology of the disease requires further elucidation; while extract of rice polishings cures the cardiac condition as well as the dropsy, the paresis persists; the substance isolated by Funk from rice polishings by precipitation with phosphotungstic acid (to which he gave the name vitamin) cures the paralysis but does not affect the cardiac disorder.

Pellagra

Pellagra is in all probability due to a deficiency of suitable protein in the dietary. This disease was first described by Casal in 1735 as existing in the Asturias where the peasants lived chiefly on maize (Indian corn) and rarely ate fresh meat. In 1771 the disease which had been observed in Italy for a considerable time was given its name, pelle (skin), agra (rough) by Frapolli. Marzari in 1810 held that pellagra and Alpine scurvy, already recognised as identical, were caused by the consumption of maize; this hypothesis has since been elaborated by Lombroso. About 1907 pellagra was found to be widely spread in the Southern States of U.S.A.; more recently its presence in this country,[1] especially in lunatic asylums, has been detected.

The disease occurs both sporadically and endemically; it is especially found among a poverty-stricken population who consume a faulty diet. In Europe the disease is most prevalent in Italy, the Balkan peninsula including Greece and Rumania, Turkey, Spain and Portugal. It is widely spread in Lower Egypt and exists in Algiers. It has been recorded in India and the Strait Settlements and is abundantly found in the West Indies, Mexico, and Central America. The disease has decreased in prevalence in Italy, 33,869 cases in 1910, as opposed to 104,607 in 1881; the case-mortality there is only about 3 per cent., much lower than formerly. In the U.S.A. the fatality has also fallen from 39 per cent. to 10 per cent.

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[1] See "Pellagra in the British Islands," Bigland, "Lancet," December 15, 1923, p. 1,295.

The course of pellagra is essentially chronic, with periodic exacerbations, but it may run a somewhat acute course with a rapidly fatal termination. The trend of events is for mild neurasthenic manifestations to appear in the winter and to be followed in the spring by disturbances of the alimentary tract: stomatitis, burning sensations travelling up the œsophagus, gastric eructations and recurring diarrhœa. The gums are often quite tender; at times they are somewhat spongy and swollen, with a tendency to bleed, hence the synonym "Alpine scurvy."

Loss of weight is a marked feature. The most characteristic sign is the eruption; this consists of strikingly symmetrical, sharply delimited patches of erythema resembling sunburn which although they occur especially on the backs of the hands and forearms, the bridge of the nose or neck (Casal's necklace and cravat) are also seen in parts such as the perineal region, where it is caused by the slight irritation of clothes or opposite parts; the patients complain of a burning sensation in the parts affected. The alimentary symptoms and the skin trouble almost completely cease in the winter, only to recur in the spring. The neurasthenia tends to pass into a toxic psychosis or even a confusional insanity; in Italy it is estimated that from 5 to 10 per cent. of pellagrins become permanently insane.

There are many theories as to the causation of pellagra. Goldberger's observations clearly show the influence of diet. One of his most striking experiences was of an orphan asylum comprising 211 children of whom 32 per cent. were suffering with pellagra. For dietary purposes the children had been divided into three groups and given different dietaries; the youngest, those under six years old, received milk and eggs, the eldest, over twelve, had meat. The children between six and twelve years old were given a strictly vegetarian diet, chiefly maize products and syrup with a small quantity of legumes. Of the children in the youngest group only two showed pellagra; one instance occurred in the 66 children over twelve, while in the intermediate groups of 120, 52 per cent., or 65, suffered. The dietary was altered; every child under twelve was given a pint of milk daily, at least one egg and more beans and peas as well as fresh meat; the disease was eradicated in a short time.

In another experiment by feeding eleven prisoners on an excessively carbohydrate diet, including maize products, he succeeded in producing symptoms of pellagra in six; it took five months for definite skin lesions to develop.

The phenomena have been explained by some as being due to a deficiency of protein in the diet. Wilson assigns to maize protein a low assimilability and considers that a person must consume 3·4 times as much maize protein as that of animal protein to fulfil the protein requirements of the body.

The disease has been produced by feeding a monkey on a diet with low protein content, most of the protein allowed being in the form of zein; abundant vitamins were present in the diet.

Goldberger and Tanner wish to narrow the deficiency to certain amino-acids. Zein, the protein of maize, is deficient in tryptophane and lysin, amino-acids necessary for proper nutrition; it is doubtful whether any cystin is present. Benefit seemed to result from administering cystin to two cases of pellagra; steady improvement in a third case followed the giving of tryptophane and cystin.

The spoiling of maize is considered by many to be an important factor in the causation of the disease.

Bellardina in 1851 advanced the view that pellagra was due to the effect of a greenish mould which he noted covering the grains. Since then attention has been directed especially to *Aspergillus fumigatus* and *A. flavescens* as well as certain species of *Penicillium* and *Mucor.*

In Corfu it was not until 1857 when maize was first imported from Rumania, and much spoiled maize brought in, that pellagra made its appearance; the prevalence of the disease in the Southern States of the U.S.A. has followed on various changes in connection with the production of maize which favour its being spoilt.

The observations recorded of late years in respect to beri-beri have influenced opinion in favour of the view that the disease is due to the absence of vitamins from the dietary rather than to infection.

It has been held that the vitamins are destroyed as the result of bacterial or mould disease of the maize or even by the fermentation and consequent heating during transport of the maize gathered when moist.

The supposed absence of the vitamins has also been ascribed to the removal of the vitamin-containing outer portion of the grain (bran) during milling. As a result of comparison of analyses of milled maize and millings obtained from different countries, Funk has suggested that the extent of pellagra in different countries is proportionate to the degree of milling. Alkalis would tend to destroy any vitamin remaining in such bread; such a practice as the use of sodium bicarbonate in the preparation of bread would favour the incidence of pellagra.

Voëgtlin has secured definite improvement by treating pellagrins with extracts prepared from fresh ox-liver and fresh pig thymus, glands rich in the fat-soluble A vitamin.

The Thompson-McFadden Commission were unable to find any evidence that distinctly pointed to maize, either sound or spoiled, as giving rise to the pellagra outbreaks ; they noted a very limited use of fresh meat in those who subsequently become attacked ; they considered pellagra to be in all probability a specific infectious disease and the infection of fæcal origin communicated from person to person, by some means at present undiscovered. Experimental results, however, seem to tell against this view ; the Commission failed to transmit pellagra to monkeys by injecting defibrinated blood from patients ; sixteen volunteers working under Goldberger for as long as six months, tried to infect themselves with blood, naso-pharyngeal secretions, epidermal scales, fæces, and urine, from pellagrins but without success. Not a single case of pellagra has ever developed among the attendants upon the pellagrous insane, or among warders guarding pellagrous criminals, or among the personnel of the U.S.A. Army and Navy, although large numbers of the men come from pellagrous districts of the south.

Lack of inorganic salts in the dietary has been held responsible by some.

Predisposing factors may be of importance : in the U.S.A. pellagra is about five times as common among women as among men ; this has been variously explained by the assumption that pregnancy and lactation predispose to pellagra or that grown women, especially wives and mothers, deny themselves the more desirable parts of the daily food.

Attention should be directed towards the long incubation period of these disorders ; during this time the body may well be in a poor state of health. For some undetermined reason the stage of definite disease may not be reached and the seat of ill-health be indefinitely continued. The whole problem of diseases caused by diet deficiency is very difficult and it is probable that research will reveal other factors of importance in their causation.

MEAT

The muscle of meat consists principally of water, protein, and salts, also of glycogen and fats stored as reserves for the animal body ; about 20 per cent. of protein is present in lean beaf.

Meat is a valuable article of diet on account of this large amount of protein which is in a form easily digested and absorbed, also by reason of its large mineral content.

The toughness of meat depends upon the thickness of the walls of the muscle tubes and the amount of connective tissue present.

Immediately after slaughter meat has an alkaline reaction ; it is tough and has a rather unpleasant flavour. *Rigor mortis* soon sets in, sarcolactic acid is developed, making the reaction of the meat acid. Meat is usually hung for some time after killing ; the flavour improves and it becomes more tender, the connective tissue being softened by the action of autolytic enzymes and bacteria.

Meat Parasites—In this country the rôle the parasites of meat play in the production of human disease is not a considerable one, this is due in a large measure to the fact that meat is not eaten raw, or practically raw. Even with an efficient system of meat inspection a single tape worm larva and the presence of trichina may be overlooked; the toxins produced by bacilli do not run the risk of being killed by the heat used during cooking. Raw meat is more digestible but not more nutritious than cooked meat.

To deal first with the higher parasites which infest the bodies of animals commonly used as food. These forms, producing as they do, in most instances, appearances which may excite suspicion, even on naked eye examination, were the first to attract attention.

There are species of tape-worm which affect man and food animals. *Tænia solium* is introduced as a rule into the digestive tract by the consumption of the larvæ present in raw or undercooked "measly pork." The affected muscles of the pig, and it may be the liver of the animal, present a mottled appearance due to the presence of numerous small oval cysts, from $\frac{1}{20}$ inch to as much as $\frac{1}{2}$ inch in their long diameter. Each cyst is a cysticercus (*Cysticercus cellulosæ*), or bladder-worm and represents an encysted larvæ of T. solium.

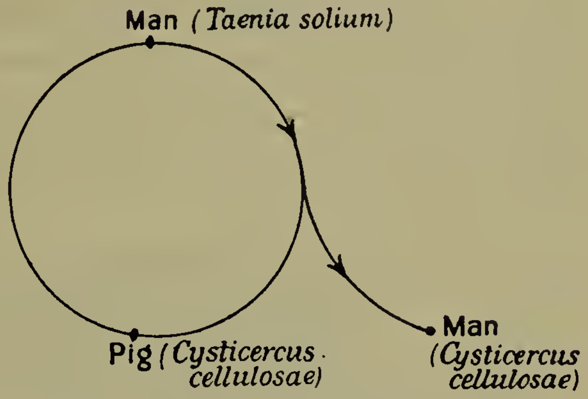
Man (*Taenia solium*)
Pig (*Cysticercus cellulosae*)
Man (*Cysticercus cellulosae*)

Fig. 27.—Life cycle of Tænia solium.

The capsule of the cysts is sometimes partly calcified and a gritty feeling is then produced on cutting through the muscle substance involved with a knife. The affected flesh becomes, moreover, flabby and soft. The larva contained in the cyst is found on microscopic examination to present a somewhat square-shaped head with a sucker at each angle, while within the circle of suckers are two successive rows of hooklets.

Thorough cooking of the pork kills the larva. The cysticercus stage is found in man, but very rarely. The infection is then contracted as the result of contamination of food with human fæces containing the ova, or from auto-infection. Serious results may follow the development of cysticerci in the brain, eye, etc., from the mechanical effects of the increased pressure thus produced.

The adult tape-worm is not of common occurrence in this country; its presence in the human intestinal canal may cause some anæmia. It sometimes attains a length of several feet, and may comprise 700 to 800 segments. The head of the adult worm is about the size of a pin, the segments adjoining it are correspondingly minute, but the largest segments attain a size of about 12 mm. by 5 mm. The eggs, which the lower segments contain in vast numbers, are round, and enclosed in a firm shell, the outside of which is thickly covered with little rods.

Tænia saginata (T. mediocanellata) is of more common occurrence in man in this country than T. solium; its presence may produce anæmia and other symptoms. The adult tape-worm attains a length of some 20 feet and includes upwards of 1,000 segments. The eggs are slightly oval, and about ·03 mm. in diameter. They appear to have a covering of little rods.

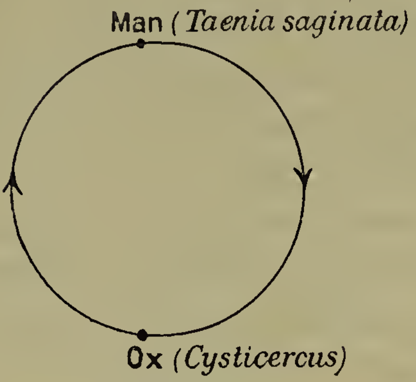

FIG. 28.
Life cycle of Tænia saginata.

The cysticercus stage (Cysticercus bovis) is passed in the ox, in which the parasite produces what is called "beef measles." The head of this cysticercus presents no hooklets, but has four prominent suckers, often surrounded by a pigmented border, while within the circle of suckers there is a pit-like depression. The cysticerci die in three weeks after killing, if the meat is kept in cold storage or in brine; thorough cooking kills the larva.

Dibothriocephalus latus passes its larval stage of development in (*a*) Cyclops and afterwards in (*b*) the pike and other *Salmonidæ*. The adult form is met with in man in Switzerland and in some of the countries bordering on the Baltic; it occurs rarely in Iceland. A greater length is attained by this worm than by the tape-worms already mentioned, the head has no suckers, but has a deep furrow or groove on each side. There are no hooklets and the body, which is ribbon-like in shape, may contain upwards of 3,000 segments. An important feature is that there is a special uterine pore in each segment from which the eggs are discharged. These can be found in vast numbers by microscopical examination of the fæces.

An anæmia resembling pernicious anæmia is produced in the human host.

Tænia echinococcus is found in its adult stage in animals of the dog tribe, the larval form is met with in man, more particularly in Australia and Iceland, and produces hydatid disease, which usually affects the liver or lungs.

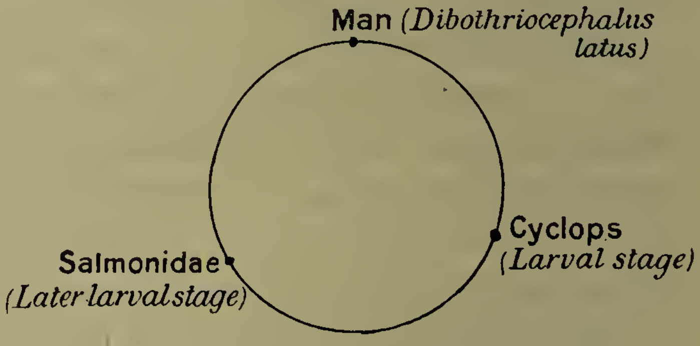
Man (*Dibothriocephalus latus*)
Cyclops (*Larval stage*)
Salmonidae (*Later larval stage*)

FIG. 29.—Life cycle of Dibothriocephalus latus.

The adult tape-worm is only about 2 inches long, and it has three or four segments; its head has four suckers and a double row of hooklets. The eggs to the number of about 500 are contained in the last segment; they are spherical in shape, and include an embryo with six hooks. On reaching the alimentary canal of man or that of some other animal, the embryo finds its way usually to the liver, and there a large cyst with numerous secondary cysts or "brood capsules," may be developed. Each brood capsule contains one or more "scolices"; each scolex possesses a ring of hooklets, and is capable, if it obtains access to the body of a dog, of developing into a mature tape-worm. It is supposed that man is usually infected by consuming uncooked vegetables or unwashed fruit upon which the eggs have been deposited, though the parasite may be conveyed by the dog in the act of licking its master.

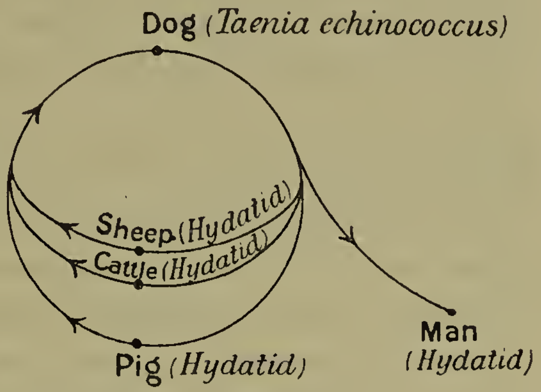

Fig. 30.
Life cycle of Tænia echinococcus.

The fact that hydatids are of not uncommon occurrence in the food-animals makes it desirable that dogs should be rigidly excluded from slaughter houses; if this be not done, by feeding on the offal they may cause contamination of the slaughterhouse, surroundings and of the meat itself, with the eggs of the adult worm.

Trichinella (*Trichina*) *spiralis* is a parasite which mainly occurs in the pig and rat. In Germany, where uncooked pork is eaten, and in the U.S.A. among Germans symptoms of trichinosis have not infrequently been observed in man. The muscles affected present numerous cysts about $\frac{1}{70}$ inch in length, which lie between the muscular fibrillæ with their long diameters disposed in the direction of the muscle fibres. The cyst walls are sometimes more or less

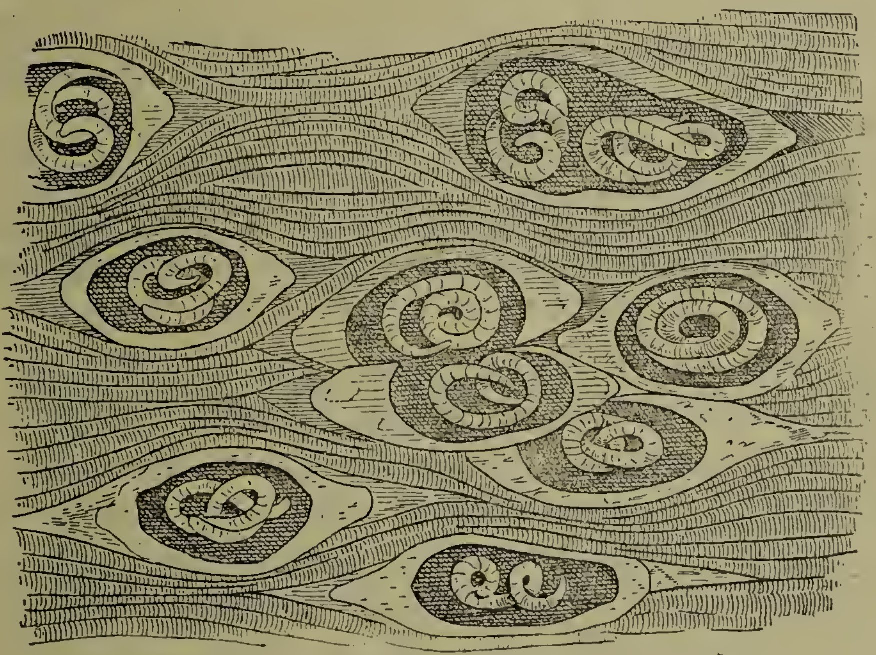

Fig. 31.—Muscle affected by *Trichinella spiralis.*

calcified and each cyst contains an immature worm about $\frac{1}{40}$ inch in length.

The diaphragm is usually a favourable site for the development of the parasite, and the intercostal muscles are also often affected. Thin sections of the suspected flesh should be made in the direction of the muscle fibres. These should be immersed for a few minutes in liquor potassæ which renders the muscle fibres translucent, and the cyst with its coiled-up worm, if present, will then be evident on examination with a low power of the microscope.

Trichinosis in man is an acute febrile affection in which muscular pains are as a rule a prominent symptom. It has been confused at times with rheumatic fever and with typhoid fever. The disease is not infrequently fatal, but its severity depends upon the number of live embryos swallowed; if a few only are ingested no symptoms may occur. Symptoms usually develop about a week after the ingestion of the diseased flesh, and last for a fortnight or more.

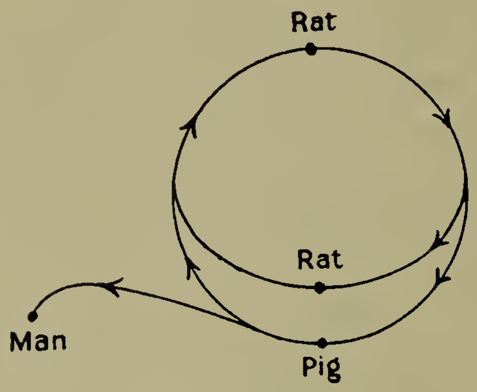

Fig. 32.
Life cycle of Trichinella spiralis.

The affected muscles become swollen and tender; œdema sometimes occurs. The voice may be hoarse, prostration is marked in severe cases, and peritonitis or pneumonia may supervene.

Prevention consists in thorough cooking of the meat, a temperature of 160° F. killing the parasite; refrigeration at a temperature of 5° F. for ten days also destroys the embryo. Pigs should not be allowed to eat uncooked offal from slaughterhouses or the carcasses of dead pigs on farms. Rats should be kept out of slaughterhouses by rat-proofing.

There are often present in the flesh of oxen, sheep, and pigs small oval or kidney-shaped semi-transparent objects known as "Rainey's capsules," or "psorospermia," these bodies are enclosed in an investing membrane with delicate linear markings, and internally they consist of granular particles, they lie within the sarcolemma of the muscle fibre, and with a little care are readily distinguishable from trichinæ; they must on no account be confused with the psorospermia often found in the liver of rabbits and some other animals.

Onchocerciasis

In 1910 nodular masses were found in quarters of beef imported from Australian ports. These nodules were found to contain a parasitic worm, Onchocerca gibsoni vel spiroptera reticulata, probably injected at an early stage of their existence into subcutaneous tissue of the bovine host by a biting insect, either Stomoxys calcitrans or Culicelsa vigilax. Although there was no evidence of vitality in the worm or its embryo in the Australian beef arriving in this country and of the direct development in man, such meat must be condemned as unfit for human food. The argument is as follows: "Certain parasites present in meat foods are of a dangerous communicable character and it would be very undesirable to encourage any attitude of indifference towards the presence of any parasitic condition in meat. There could, moreover, be no question that meat affected with onchocerciasis must be classed as unsound: both the worms and the local inflammatory products which result from their invasion are foreign to sound meat and are objectionable to the meat consumer."

Members of the diptera, coleoptera and lepidoptera lay eggs on food of all kinds; meat, garden and hedgerow fruit, cabbages, salad vegetables, onions and radishes, water, cakes, biscuits and sweets have all been infected. Under some conditions these eggs are hatched in the human stomach and in chronic cases patients may suffer from emaciation, anæmia and general debility (*myiasis*).

Meat Inspection[1]

Recognition of the risk of tubercle from the consumption of meat emphasised the necessity of adequate inspection by trained inspectors of animals at the place of slaughter in order to give opportunity for thorough investigation, not only of the flesh, but of the lungs and other viscera and of the carcass generally. The Ministry of Health in a Memorandum $\frac{62}{\text{Foods}}$ dated March, 1922, set out and recommended a system of meat inspection for adoption by local authorities.

The more important recommendations are that all animals should be inspected before being slaughtered. Notice of intention to slaughter animals for emergency reasons should be given and the carcasses inspected. [The flesh of animals slaughtered in a dying state, or which have died, is generally dark and discoloured by reason of not having been bled, and such flesh sets badly and quickly decomposes.]

Butchers and slaughterers should not interfere with any evidence of disease before it has been seen by the meat inspector.

Wiping cloths used for tuberculous carcasses should be separate, and after use boiled for 15 minutes in water containing soda; knives used for cutting any diseased part should be disinfected before further use.

A mode of examination of carcasses is laid down. All viscera are to be examined under circumstances to ensure that they are the viscera of a particular carcass. Every organ and the associated lymph glands are to be examined by inspection and palpation and if necessary incision.

The carcass should be examined for (1) condition of nutrition; (2) evidence of bruising, hæmorrhage or discoloration; (3) local or general dropsy (œdema); (4) the efficiency of bleeding; and (5) swellings or deformities of bones or joints or swellings or other abnormality in the musculature.

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[1] Two standard textbooks on food inspection are: "Meat Hygiene," by Edelmann, Mohler and Eichhorn; and "Inspection of fish, game, fruit, etc.," Walker.

The serous membranes (pleura and peritoneum) shall be examined in every case, and in no case shall they be removed nor shall any evidence of disease be modified or obliterated by washing, rubbing, stripping, or in any other manner before examination.

The presence of hæmorrhagic points in the fat, the existence of evidence of emaciation in the carcass, or signs of pleuritic adhesions, and especially any indication of the fact that the pleura has been stripped with a view to concealing the existence of such adhesions, all point to the conclusion that the meat is diseased and unfit for food.

Detailed instructions are given for the routine inspection of the carcasses of bovines and swine. Stress is laid on the examination of lymphatic glands. In *all* cases the following glands must be examined as a matter of routine, viz. :—(1) Retropharyngeal (in bovines) and submaxillary (in swine); (2) bronchial and mediastinal; (3) hepatic and (4) mesenteric.

In reporting on lesions of the stomach, intestines and spleen, liver and ovaries special attention shall be paid as to whether the lesions affect the peritoneal surface or the organ itself.

Where as a result of the inspection evidence of tuberculosis has been detected, the carcass and viscera shall be further examined in accordance with the following instructions :—

1. The viscera and the associated lymph glands shall be examined for evidence of tuberculosis both in the substance and in the covering membranes (capsules). *The existence of tuberculosis in the lymph gland of an organ shall be held to be evidence of the disease in the organ.*

2. All the usual lymph glands which are examined in meat inspection work (other than those already enumerated), *viz.* :—the lower cervical, pre-sternal, supra-sternal, sub-dorsal, pre-scapular, supra-mammary (or superficial-inguinal), iliac and sub-lumbar glands; and, if considered necessary, the pre-crural and popliteal glands shall be exposed and examined by incision in every case of tubercle. Those glands which, having regard to visible evidence are least likely to be infected, shall be examined first, *e.g.*, if evidence of tuberculosis is found on the pleura the glands of the hind quarter shall be examined before those of the forequarter.

3. The carcass of a pig in which lesions of tuberculosis are found in any situation or in any degree shall be split and the vertebræ examined. The kidneys in such a carcass should be freed, but not necessarily detached from the enclosing fatty tissue, the surface should be carefully examined, and if lesions are obvious or suspected, incisions should be made into the substance.

Instructions are laid down as to the action to be taken when evidence of tuberculosis is found in bovines and swine.

A.—*Organs.*

An organ shall be seized when tuberculosis exists on its capsule, or in its substance, or in the associated lymph glands.

B.—*Head.*

1. The head, including the tongue, shall be seized if any of the lymphatic glands of the head are affected.

C.—*Carcass.*

1. The entire carcass and organs shall be seized when the following conditions are found :—

(*a*) Tuberculosis with emaciation.
(*b*) Generalised tuberculosis.

In determining whether the disease is generalised, the judgment shall be based on the sum of the evidence of disease throughout the entire carcass and organs. The following conditions shall be regarded as evidence of generalisation :—

(i) Miliary tuberculosis of both lungs. (*Note.*—This regulation is subject to the following qualification :—In minor instances of miliary tuberculosis of the lung, without evidence of tuberculosis elsewhere and provided the miliary tubercles are not numerous and not of recent origin, it may be possible to pass the carcass. But miliary tuberculosis of the lung even in such a case is evidence of previous systemic infection, and the decision as to whether such a carcass should be condemned should devolve upon the veterinary inspector or the medical officer of health.)

(ii) Where lesions are multiple, acute, and actively progressive.

(iii) Where there is multiple and widespread infection of the carcass lymph glands.

(iv) Where there are diffuse acute lesions of both serous membranes (pleura and peritoneum) and any of the carcass lymph glands are enlarged or contain visible tuberculous lesions.

(v) Where, in addition to the presence of tuberculous lesions in the respiratory or digestive tracts, there are also lesions present in the substance of any one of the following—spleen, kidney, udder (or uterus or ovary), testicle, brain and spinal cord or their membranes. (*Note.*—Notwithstanding this instruction instances may be found where it would be justifiable to pass the carcass after condemnation of the affected organ. Absence of signs of activity, such as calcification or definite encapsulation would be favourable indications. The decision as to whether such a carcass should be condemned should devolve upon the veterinary inspector or the medical officer of health.)

(vi) Congenital tuberculosis in calves.

2. All cases of tuberculosis not included in the immediately foregoing regulation shall be regarded and treated as localised lesions, and the parts containing the lesions and contiguous thereto shall be condemned.

3. If an organ or portion of a carcass becomes contaminated by tuberculous material, it shall be treated as if it were a case of localised tuberculosis.

Advice is given as to the action to be taken in the event of any other disease being found in the carcasses of bovines, swine, sheep or horses. The entire carcass and all the organs shall be condemned if evidence of any of the following conditions is found :—

Actinomycosis, generalised. This disease as a rule involves the tongue and lower jaw of the ox ; it may also occur in the lungs, alimentary tract, and in other parts. It has not been shown that the disease has been communicated to man by the consumption of the flesh of animals suffering from actinomycosis, but the only safe course is to condemn such flesh.

Anæmia (if pronounced).

Anthrax.[1] Although this disease is probably not often communicated to man by means of food the carcasses of animals affected with the disease should be unhesitatingly condemned.

Blackleg (Blackquarter).

[Braxy is not dealt with in the Memorandum ; the term as applied to disease in sheep appears to include more than one morbid condition. The flesh in cases in which braxy has been diagnosed is usually altogether abnormal in appearance, and quite unfit to be eaten.]

Bruising, general, extensive and severe, with or without gangrene.

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[1] The meat inspector should, in accordance with the Diseases of Animals Acts and Orders made thereunder, notify the disease to a constable of the police area or the inspector of the local authority under the Acts.

Cysticercus bovis (measly beef), if generalised in the meat substance.

Cysticercus cellulosæ (measly pork), if generalised in the meat substance.

General decomposition (indicated by an offensive smell, marked discoloration or iridescence).

Signs of early decomposition are pallor and softness, the meat juices lose their acid reaction, a greenish tinge appears. The odour of putrefaction if not readily observed may be detected by a skewer or knife thrust into the interior of the meat and withdrawn; an auger and bit is required for frozen meat. This examination elicits the presence of "bone taint," deep seated putrefactive changes in the thick muscles especially of the hip but also of the shoulder.

General dropsy (a flabby sodden condition of the meat).

Emaciation, general pathological (associated with disease).

Erysipelas, acute swine.

Fever (acute).

Foot and mouth disease.

The decision as to whether animals affected with this disease shall be slaughtered or otherwise disposed of rests with the officers of the Ministry of Agriculture and Fisheries. If the carcasses and organs of such animals are submitted for human food, the decision as to their fitness for this purpose should devolve upon the Medical Officer of Health or Veterinary Inspector authorised or appointed by the Local Authority. In any case, where it is found that the disease is strictly localised, that no signs of septic infection are present, and that there is entire absence of any indication of fevered condition such as wasting, hyperæmia of the internal organs or of the lymphatic glands and of other complications which may arise as sequelæ of the disease, it will be for the consideration of the officers mentioned whether the carcass may (in other words, should) be passed for human consumption after removal of the head and feet.

Glanders (or farcy).

Immaturity, stillborn or unborn carcasses.

Immaturity.—A carcass shall be considered too immature to produce wholesome meat if—

(*a*) The meat has the appearance of being water-soaked, is loose, flabby, tears easily, and can be perforated with the fingers; or

(*b*) Its colour is greyish-red; or

(*c*) Good muscular development as a whole is lacking, especially noticeable on the upper shank of the leg, where small amounts of serous infiltrates or small œdematous patches are sometimes present between the muscles; or

(*d*) The tissue which later develops as the fat capsule of the kidneys is œdematous, dirty yellow or greyish-red, tough and intermixed with islands of fat.

Jaundice.

Lymphadenitis, caseous, a disease caused by the Preisz-Nocard bacillus.

Malignant catarrhal fever.

Malignant neoplasms—unless localised, in situation and effect, to one organ.

Mammitis, acute septic.

Melanosis, generalised—or any generalised pigmentation.

Metritis, acute septic.

Uræmia (or carcasses having a urinous odour).

Pericarditis, septic.

Pneumonia, gangrenous.

Pleuro-pneumonia is a disease which occurs in the ox not transmissible to man; if the flesh presents no marked deviation from the normal appearance, it is usually passed as fit for food.

Pyæmia—including joint-ill, or umbilical pyæmia.

Rickets with malnutrition.
Sarcocysts—if generalised in the musculature and visible to the naked eye.
Septicæmia, or septic intoxication.
Swine fever.[1]
Tetanus.
Trichinosis.
Tumours, multiple in musculature.

Diseases apparently not dealt with in the list are Variola ovina and "rot" due to liver fluke. Carcasses of sheep affected with *Variola ovina* should be condemned. The liver fluke *Distoma hepaticum* produces "rot" in sheep. The parasite is shaped like a very small sole, and it is about one inch in length. Provided the flesh is not abnormal in appearance, the risk from consuming it is practically infinitesimal; but animals suffering from the malady often become emaciated and dropsical, and when this is the case the carcass should of course be condemned.

The flesh of animals that have been overdriven, or have been slaughtered during parturition often presents abnormal appearances, but such flesh need not necessarily be regarded as unfit for food provided the departure from the normal condition is but little marked.

The Memorandum goes on to say in all cases in which evidence of diseases not enumerated in the Memorandum is found the organ or portion of the carcass (or organs or portions of the carcass) affected by the disease, and the organs or portions contiguous thereto, shall be condemned.

Such a system of inspection is very much facilitated when slaughtering is conducted in public abattoirs; in many towns abroad, and in not a few in this country, the necessity for this has been recognised. Meat is stamped with a distinctive mark in Belfast, Exeter, Hamilton, many of the Continental towns, and Alexandria among others, before it is allowed to be removed from the abattoir for sale. In certain Continental towns [2] meat which is regarded as suspicious is treated by being boiled—pickled in the case of swine erysipelas and fever—frozen in that of lesser infestation with measles, or the fat from tuberculous carcasses is removed under high temperature and the rest of the carcass destroyed; the meat is then sold at special premises, the Freibank.

Meat from tuberculous animals or animals containing cysticerci and trichina or which have suffered from hog cholera, swine plague, certain forms of icterus, or animals which have recently given birth to young is included under this heading.[3]

The chief abnormalities found in imported carcasses other than those mentioned above are the presence of *brine staining* (leaking pipes used for refrigeration allow the solution of calcium chloride and dilute sulphuric acid to drip on to the meat and bring about condemnation of the affected part); *white moulds* which can be rubbed off the outside of the carcass and *black moulds* which cannot be rubbed off and cause condemnation of the meat. Frozen meat is brought over here at a temperature of 18° F.; if this temperature is not maintained and the meat exposed to the air, *i.e.*, is not covered by muslin, etc., the moulds grow. Chilled beef is imported chiefly from the Argentine at a temperature of 27° F. It might be as well to explain two terms used in the meat trade—" slink calf " or " bob-veal," calves only 4–5 hours old; the eating of this meat is said to give rise to diarrhœa, but this is very doubtful. " Slink meat " is the flesh of old cows.

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[1] *See* footnote on page 191.

[2] The practice is slightly different in the U.S.A., but the same sale of the meat of a grade intermediate between that undoubtedly fit for human food and that undoubtedly unfit (the so-called three grade standard) is in force. See Howarth, "Meat Inspection Problems" (Milroy Lectures, 1917, p. 34).

[3] See Howarth, *loc. cit.*, pp. 129, 130. These lectures include on p. 131 *et seq.* the reasons why permission to inaugurate the sale of sterilised unsound meat in this country is generally considered inadvisable. Other subjects dealt with by him which should be mentioned in this note are boneless and canned meat and the inspection of imported carcasses.

Slaughterhouses and Abattoirs

Much opposition has been encountered in this country to the institution of public abattoirs as it has been alleged that the attractive appearance of home-killed meat can only be produced when the butcher has the opportunity of preparing animals for slaughter and killing them on his own premises in which the carcass can be afterwards hung, and allowed to set properly.[1] The handling of freshly-killed meat, and its removal immediately after slaughter doubtless interferes with this setting process, but this difficulty has been met by the provision of cold storage, and the advantages of the private slaughter-house are now no longer apparent. On the other hand, the disadvantages arising from multiplication of such establishments, to an extent which makes it practically impossible to exercise supervision as regards the fitness for food of the meat dealt with, and the lack of facilities for examination of the carcasses, render their abolition most desirable, apart altogether from the nuisance which is likely to result from the continued existence of such places in close proximity to houses.

The Jewish *method of slaughtering* consists in cutting all the large vessels of the neck with one sweep of the knife.[2] In London cattle and sheep must first be effectually stunned by a mechanically operated instrument (*i.e.*, a mechanical pistol); no hindrance to the subsequent bleeding of animals is caused nor is the keeping quality of the meat of animals killed by this method lessened. In pigs killed by being shot in the brain extravasations (" blood splashings ") are stated to occur disfiguring the meat and lessening its selling-price when converted into bacon and ham.[3] A scientific reason for avoiding the contamination of meat in slaughter-houses, by splashing and so forth with the intestinal contents, is that these in the case of animals which have suffered and recovered from infection with one of the Gärtner group, may still contain the bacilli.

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[1] For other trade and lay objections, see Howarth, *loc. cit.*, p. 33.

[2] Reference may be made to a Report of a Committee appointed by the Admiralty to consider the humane slaughtering of animals (Cd. 2150).

[3] This is not credited in Denmark, famous for its bacon.

Abattoirs should be built near a railway to do away with the necessity of driving cattle through the streets and to facilitate transportation generally. An abattoir must be constructed so that it can be kept scrupulously clean and keep out rats and mice and flies. Facilities for washing the hands should be provided; the sanitary accommodation must be separated from rooms in which the carcasses, etc., are dealt with. A room should be set apart for the inspection of all carcasses and parts which require careful examination. All condemned meat should be put in a room devoted to this purpose until it can be rendered unfit for food purposes by exposure to steam under high pressure or slashed with a knife and treated with kerosene or other malodorous liquid, or a colouring fluid such as methyl violet.

Horseflesh is rich in glycogen. It can be sold for human food if it is sold as horseflesh; to supply it to a consumer as other meat, or in sausages, etc., is a contravention of the provisions of the Sale of Horseflesh, etc., Regulation Act, 1889. The flesh of the horse is darker and coarser as a rule than beef, and possesses a characteristic odour. The fat is yellower than beef suet, and has a peculiar taste.

The species of the animal from which a particular piece of meat has been derived can be readily determined by means of the precipitin reaction. By injecting rabbits with an unheated watery extract of the meat a substance, precipitin, is formed in their blood. When the serum of such a rabbit is added to a clear solution of a watery extract of horseflesh, for example, if the meat originally used were derived from a horse a precipitate will be formed.

A careful examination of the fat of the meat, its crystalline form, melting point and the nature of the fatty acids obtained from it—different for each species of animals—will also enable the species to be traced.

Fish

Fish possesses high nutritive value and is, as a rule, readily digestible; improved means of communication and of preservation have led to increasing use of this form of food, especially by poor persons dwelling in large towns at a distance from the coast.

Fish harbour numerous parasitic worms which are not transmissible to man; of these an immature round worm *Ascaris* is often found in cooked fish. Apart from the feeling of disgust which the discovery arouses it is, however, of no importance. Freshwater fish of the family *Salmonidæ* harbour the young stage of the broad tapeworm of man (*Dibothriocephalus latus*). In Switzerland and the Baltic countries, the pike and the "lotte" are frequently infested and the local population acquire the infection from the consumption of the undercooked flesh. Occasional cases have been recorded from the West of Ireland. Poisoning has resulted in some instances from consumption of fish; mackerel in particular, a fish which undergoes decomposition with special facility, has been said to occasionally produce gastro-intestinal disturbance.

The part played by shell-fish and fish in the spread of typhoid fever is considerable; it is dealt with elsewhere (see p. 523). Cholera is also spread by the consumption of shell-fish (see p. 405). Attacks of acute poisoning not infrequently fatal have followed the consumption of mussels. The symptoms are due to involvement of the nervous system: prickly pains in the hands and feet, dyspnœa, want of co-ordination of movement and spasms especially of the arms. Signs of gastro-intestinal irritation may be absent. Copper derived from ships' bottoms, etc., cannot be excluded as the cause in some instances; in others the fault lies in chemical poisons formed by the growth of bacteria derived from sewage in the vicinity. Other less probable sources are the spawn of the starfish, a poison contained in the gills of the mussel, and a small crustacean (*Pinnotheres pisum*) which is sometimes found in the mussel's gills. In an outbreak which occurred at Wilhelmshaven, in 1885, it was found that a toxic principle could be extracted from the liver of the implicated mussels. Brieger thus isolated a ptomaine, $C_6H_{15}NO_2$, which he termed mytilotoxine, and which he supposed was produced by a special bacterium. This ptomaine he held to be the immediate cause of the symptoms of mussel poisoning.

Milk contains certain proteins (of which the most important is casein), carbohydrates (lactose), and mineral salts in solution, and it holds in suspension microscopic globules of fat. The globules rise to the surface when the milk is allowed to stand, forming cream. The amount of cream present may be determined by allowing the milk to stand for twelve to twenty-four hours in a cream tube, a cylindrical tube provided with a graduated scale at its upper part, upon which the amount of cream which separates can be read off. On the average, the yield of cream should be about 8 to 10 per cent., though in the case of the milk of Alderney cows it sometimes exceeds 30 per cent. More complete separation than is obtainable by merely allowing the milk to stand, can be effected by centrifugalisation in a "separator." The specific gravity of milk varies from about 1027 to 1034; it is determined by means of a lactometer. Regard must be paid to the temperature at which the estimation is made: each rise of temperature 10° F. above 60° F. corresponds, roughly speaking, to a fall of 1 degree in the specific gravity of milk. At 60° F. a fall of about 3 degrees in specific gravity is produced by the addition of 10 per cent. of water to the milk. Skim milk is of higher specific gravity than whole milk and thus by the addition of water to skim milk the fluid may again be reduced to the specific gravity it originally possessed before the cream was removed.

Cow's milk contains more protein and salts and less carbohydrate than human milk. Hence in using cow's milk for young infants it must be diluted so as to imitate as nearly as possible the proportions in which proteins and salts exist in human milk, and further to make up for the deficiency of carbohydrates by the addition of milk sugar. An important difference between cow's and human milk, moreover, lies in the fact that while the latter forms a loose, flocculent curd, when it is acted upon by the digestive juices, the tendency of the former is to clot in masses, which are less readily digestible. Ass's milk approaches human milk more nearly in composition than cow's milk but is deficient in fat. Goat's milk contains excess of both fat and protein as compared with human milk; the use of milk of this animal is advocated on the ground that the goat rarely suffers from tuberculosis. Both ass's and goat's milk yield a flocculent curd. Mare's milk affords considerably less fat and less protein than human milk; "Koumiss" is prepared from mare's milk; part of the cream is removed, and a fermentation process is then set up, by which some of the milk sugar is converted into lactic acid.

Cow's milk varies in composition according to the breed, the age, the period since calving, and the number of pregnancies of the cow from which the milk is obtained. The season of the year, the stage of milking, the nature of the food given to the cow, and the conditions under which the animal is kept, also exercise influence. The "fore-milk," that first drawn, contains very little cream; the "strippings," the milk last drawn, contain excess of cream. Much discussion has therefore arisen as to what should be accepted as the minimum standard for the various ingredients of pure milk. It is usual to fix the limit at 3 per cent. in the case of fat, at 8·5 per cent. for the "solids-non-fat," and at ·7 per cent. for the ash.

A Departmental Committee was appointed by the Board of Agriculture to inquire and report upon the desirability of Regulations under Section 4 of the Sale of Food and Drugs Act, 1899, for milk and cream. A majority of this Committee recommended that if the total solids do not amount to 12 per cent. the presumption should be raised until the contrary is proved, that the milk is deficient in the normal constituents of genuine milk. Further, that if this limit be not attained, and either the amount of milk fat be less than 3·25 per cent. the presumption should be raised until the contrary is proved, that the milk is adulterated. The Committee made also other suggestions, among which was included the recommendation, that separated milk should be branded, or "ear-marked" by the addition of some suitable and innocuous substance. The Sale of Milk Regulations, 1901, issued by the Board of Agriculture, do not follow the Committee's finding, but merely stipulate that if there be less than 3 per cent. of milk fat, "it shall be presumed for the purposes of the Sale of Food and Drugs Act, 1875 to 1899, until the contrary is proved that the milk is not genuine." Regulations also fix 8·5 per cent. as the limit of milk solids in ordinary milk and 8·7 per cent. in skimmed or separated.

Milk is so frequently adulterated and contaminated that some knowledge of its production and distribution is necessary. The excellence of milk as an article of diet also makes it advisable to increase the production and consumption of milk. Milking trials have indicated the breeds which give the heaviest yield of milk—Dexter, Ayrshire and Jersey, and milk with the highest fat content—Jersey, Dexter and Guernsey. For cheese production the percentage of total solids is important; the best animals for this purpose are the Dexter, Jersey and Ayrshire cattle. The cost of milk production depends chiefly on the cow's food, the cost of labour and the depreciation of animals through disease such as tuberculosis. Housing of the cattle from October to May costs less in food but more in labour; their health is not so good as that of animals kept out of doors day and night, summer and winter. The proper ration for a cow has now been worked out on scientific lines.

Milk is spoilt by external contamination, high temperature and age; this can be prevented by clean milking and handling, use of clean containers and speedy delivery.

The main factors in clean milking are the use of milking cans with a guarded opening at the side instead of a completely open top which allows dried manure, etc., from the cow's body to fall into the can; these and the milk churns must be sterilised; the milking must be dry, *i.e.*, the milkers must not moisten their hands with saliva.

The cows must be housed in clean, well lighted and well ventilated cow-sheds provided with an ample water supply. The cows must be kept clean, their udders should be wiped with a clean moist cloth just before milking, no straw litter should be used. The first few squirts of milk from each teat should be rejected as the orifices of the teats and the main ducts of the udder become infected with organisms between the times of milking.

In the dairy the milk is passed over a cooler into the churns which should not hold more than ten gallons. Straining should be carried out here and cotton wool pads used; these can be thrown away at once after use. Any straining cloths should be boiled after each milking.

A scheme of grading milk according to its purity was introduced in the Milk and Dairies (Amendment) Act of 1922 and the Milk (Special Designations) Order of 1923 sets forth the principal conditions applying to the various classes of milk.

Milk.	The Number of Bacteria must not exceed	No Coliform-bacillus must be present in
Certified	30,000 per c.c.	0·1 c.c.
Grade A and Grade A (tuberculin tested)	200,000 per c.c.	0·01 c.c.
Grade A Milk Pasteurised . .	30,000 per c.c.	0·1 c.c.
Pasteurised	100,000 per c.c.	——

In the case of certified milk and Grade A (tuberculin tested) milk the herd is to be submitted to an examination by a veterinary surgeon and to a prescribed tuberculin test at intervals of six months. Neither of these milks may be treated by heat; the milk is to be bottled on the farm.

For Grade A milk each milch cow must be examined three monthly by a veterinary surgeon; the milk is to be bottled or placed in a sealed container of less than 2 gallons capacity at the farm or dairy; it is not to be treated by heat.

Are the enormous numbers of bacteria present in milk especially during hot weather actually harmful? W. H. Park considers that we have only to refer to the universal clinical experience, that a great number of children in cities sicken on the milk supplied in summer, that those put on milk which is sterile or contains few bacteria as a rule mend rapidly, while those kept on the impure milk continue ill or die. [It is possible that while some organisms are harmless in themselves the products of their growth in the milk are harmful.]

Our knowledge is probably as yet insufficient to state just how many bacteria must accumulate to make them noticeably dangerous in milk. Some varieties are undoubtedly more harmful than others and we have no way of restricting the kinds that will fall into milk except by enforcing cleanliness. We have also to consider that milk is not entirely used for some twelve hours after being purchased, and that during all this time bacteria are rapidly multiplying especially where, as among the poor, no provision is made for cooling it. Slight changes in the milk which to one child would be harmless would in another produce disturbances which might lead to serious disease. A safe conclusion is that no more bacterial contamination should be allowed than it is practical to avoid.

Pasteurisation is defined to mean retention at a temperature of not less than 145° F. and not more than 150° F. for at least half an hour and immediate cooling to a temperature of not more than 55° F.; the milk is required not to be heated more than once. All pathogenic organisms are destroyed with the possible exception of the tubercle bacillus.[1] About 99 per cent. of the non-pathogenic bacteria are destroyed; as however some lactic acid producing organisms remain the milk should be cooled immediately after pasteurisation.

By heating to this temperature the taste and flavour of the milk are scarcely altered; the line of demarcation between the milk and cream becomes less distinct when a temperature of 148° F. is reached. At 150° F. about 5 per cent. of the milk albumin is rendered insoluble but not necessarily less digestible. The enzymes are slightly affected.

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[1] See paper by Campbell Brown, "Lancet," August 18, 1923.

The soluble calcium and magnesium phosphate are not precipitated. Both fat-soluble A vitamin and water-soluble B vitamin have a relatively high resistance to heat and are not affected by pasteurisation. But the anti-scorbutic property of milk is lessened by the heating; the anti-scorbutic vitamin is sensitive to heat above 122° F. Although it is stated that the destruction of vitamins appears to be due to oxidation and exclusion of air during pasteurisation would safeguard the vitamins no experiments bearing directly on the point appear to have been performed. The apparatus used in commercial pasteurisation can be classified as (i) flash—in which milk is very rapidly heated to a relatively high temperature and then cooled, (ii) retarders which delay the flow of milk through the apparatus and keep it at the pasteurisation temperature for a prolonged period, (iii) holders in which the milk can be held at the required temperature for a definite period and (iv) the apparatus used for pasteurising milk in bottles; of these the holder type alone is satisfactory.[1]

Preserved milk has of late years come largely into use.

Condensed milk is preserved with cane sugar which merely inhibits the growth of organisms, unsweetened milk is sterilised by heating to a high temperature, but may become contaminated during cooling and packing. Both forms are concentrated usually to one-third of their former bulk but occasionally only to one-half. Probably vitamin A and B are lost by condensing milk.[2]

Dried Milk—Milk is dried by several processes; by spraying on the inner surface of a rotating steam-heated cylinder inside which the atmospheric pressure is reduced; at a higher temperature by spraying previously concentrated milk on the outer surface of revolving steam drums heated to 230° F., the dried deposit being scraped by knives (Just Hatmaker process), or by spraying milk previously concentrated in a vacuum into a large drying chamber containing hot air, thus causing the particles of the spray to dry instantly (Bénevot-de-Neveu process).

Dried milk is more digestible for infants than ordinary milk, the curd being more flocculent and finely divided. Milk dried by spraying does not lose its fat soluble or water soluble vitamins. Hess and Unger found that milk does not lose its anti-scorbutic properties to any extent if dried quickly.

In *homogenised milk* the cream is evenly distributed throughout the milk; its nutritive value is diminished by the process as the vitamins are partially destroyed by the oxidation brought about by the air forced into the milk.

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[1] See Report No. 17 of Ministry of Health on Pasteurisation of Milk. Hamill, 1923.

[2] See pp. 97, 98, "Canned Foods in Relation to Health," Savage.

Milk in Relation to Disease

Milk readily becomes contaminated by gases and effluvia to which it is exposed. Thus the former practice of selling milk in shops where it is kept in close proximity to paraffin oil leads from time to time to complaint being made with regard to the taste and smell of milk. So far as such sources of contamination are concerned, it is very doubtful whether any serious injury to health is produced, but at the same time the milk is rendered less acceptable to the consumer.

The possibilities of pollution by drainage effluvia, by emanations from decomposing organic matter, and by exposure to the atmosphere of dwelling-rooms (or, indeed, to the air of ill-ventilated rooms generally) all need to be carefully borne in mind, as they may involve risk of communication of harmful property to the milk.

In some instances it has been found that metallic impurity (lead and copper) has been taken up from vessels in which milk has been stored. Unless milk measures, churns, etc., are kept scrupulously clean, there is liability to collection of materials derived from the milk, and of foreign substances in crevices and corners, and this source of contamination requires to be carefully looked into.

Milk which has become sour is apt to produce digestive disturbance, particularly in babies; the fact that the epidemic diarrhœa of warm weather is comparatively rare in breast-fed infants, but common among children brought up by hand, makes it specially necessary to take every possible precaution with a view to avoiding contamination, especially in the home. The milk is at times boiled or "pasteurised" as an additional precaution, but heat does not necessarily affect the chemical poisons produced by the growth of bacteria, and it is not desirable to attempt to bring about the destruction of resistant spores.

The milk of cows may be rendered abnormal in quality in consequence of peculiarities in the animals' food. Thus cows which have eaten *Rhus toxicodendron* have been found to yield milk which causes severe gastro-intestinal symptoms and weakness and ill effects occur after the use of the milk of animals fed upon distillery swill, which in addition to the bad flavour which it gives the milk may cause the secretion of small quantities of alcohol, which have proved deleterious to calves and lambs as well as children fed on it. Various drugs, such as opium, volatile oils, purgative salts, potassium iodide, administered to cows alter the quality of the milk.

Milk should not be used within fifteen days of parturition or during the first five days after parturition. The ingestion of such milk "colostrum" is liable to produce diarrhœa, colic, and other digestive disturbances.

In cases in which milch cows are affected with anthrax, the specific bacillus has been found in the milk. Actinomycosis, although rarely located in the udder, requires condemnation of the milk if the disease be located in this gland; the same holds of botryomycosis, cowpox and rabies. The milk of cows affected with gastroenteritis changes quickly to a sweet curd and is apt to produce digestive disturbances in the consumer.

The presence in the dairy of cows affected with such septic conditions as puerperal sepsis, septic metritis, abscess of the udder, diffuse phlegmon, suppurative wounds, and extensive ulcerations constitutes a grave danger to the milk supply, inasmuch as the milk may become infected with the pus-producing organisms, among which the streptococci are capable of causing enteritis in man; the milk of cows suffering from febrile conditions, especially when associated with sepsis, should also be excluded.

Milk sickness, a disease of cattle transmissible to humans by the infection of flesh, milk or dairy products occurs especially in the middle states of U.S.A. In man the onset of the disease is marked by extreme weariness, vomiting, retching and insatiable thirst. Respirations become laboured, peristalsis ceases, the temperature is subnormal, and the patient becomes apathetic. Paralysis gradually follows and death takes place quietly without *rigor mortis.* The disease is limited to low swampy uncultivated land and often to one or a few acres; it rapidly disappears when the land is cultivated or drained. A spore forming bacillus B. lactimorbi has been isolated by Jordan and Harris from the blood and organs of animals who have died from this disease.

The "thrush" of infants has been attributed to the presence of *Oidium albicans* in milk, and other fungi have been described as being present in instances in which gastric disturbance has been observed to follow the use of milk.

In many acute constitutional diseases of the cow the yield of milk is lessened or ceases altogether; in tuberculous disease the amount of milk secreted is often considerable, even in the later stages of the malady.

Slimy, stringy, or ropy milk is not infrequently seen; it is the result of a diseased condition of the udder of the cow although in the majority of cases the abnormal appearance is caused by various species of bacteria infecting the milk after it has left the udder. While this altered milk may be perfectly wholesome it is nevertheless unpalatable, and most consumers in this country would rather do without than drink such a fluid.

A bitter taste may also be dependent upon the cow, or due to the growth of bacteria in the milk after it has been drawn from the animal. The difference between these two classes of milk is that the first has a decidedly bitter taste when freshly drawn, while the second class is sweet when taken from the cow, but the bitterness occurs after standing for a short time and increases in intensity. Bitter milk, when produced in the cow, may result from improper feeding with such herbs as lupins, wormwood, etc., or with raw Swedish turnips, cabbages, etc. Bitter milk may also be observed during the late stage of lactation and has followed the infection of teat ducts with bacteria which act on the proteins as an enzyme, converting them into peptones and other products to which the bitter taste is probably due.

The poisonous alkaloid tyrotoxicon (diazo-benzene butyrate), isolated by Vaughan from cheese, has been found to be present in rare instances in milk.

General character of Milk-borne Outbreaks

Milk acts as a means of conveying the infection of specific diseases —typhoid fever (see p. 522) scarlet fever (see p. 478), septic sore throat, diphtheria, tuberculosis, diarrhœa and rarely foot and mouth disease.

There are certain peculiarities of milk-borne outbreaks which are deserving of note. In the first place, the outbreak is usually sudden in its appearance, the persons attacked developing symptoms almost simultaneously, thus precluding the possibility of attributing any considerable proportion of cases to direct infection from earlier cases. Again, multiple house invasions are of common occurrence. Further it is usually found that the households in which large quantities of milk are consumed suffer to a disproportionate extent, and in cases in which milk is stored or kept overnight, there seems to be greater liability to attack; persons who only take milk in tea or coffee, or who are in the habit of boiling the milk before using it, have moreover been found to escape. Again, the incidence of the disease is greater upon young children and women than upon men.

Although the mortality is held to be usually low, extended observations have shown that this view is incorrect and the mortality from outbreaks due to infected milk may be about the same as that occurring in other outbreaks.

The source of infection may be the hands of the milker, especially if wet milking is carried out; the air and dust of the cowshed, the pollution being derived both from the human and animal occupants; the milk pail; water supply; milk cooler; churns; handling during transport; receptacles including bottles and cans contaminated by the retailer, during the tasting of milk by retailers or their agents; the contamination of bottles and cans by the consumer drinking out of these receptacles or by infected hands or articles used during cleansing by the consumer.

Septic Sore Throat—Not uncommonly [1] outbreaks of septic sore throat, usually accompanied by other complications, are spread by milk contaminated with streptococci, a bovine mastitis being present. The milk consumed by the sufferers is derived from a common source where cows with mastitis have been discovered and whose milk has been consumed with that of the rest of the herd. In an outbreak in Boston, U.S.A., in 1917, the strain of streptococcus present in the discharge from the udder was identical with that obtained from the sore throats of the sufferers. In an outbreak in Portland, Oregon, U.S.A., the dairy concerned supplied about 1,200 persons; 487 cases occurred with 22 deaths.

Foot and Mouth Disease—Foot and mouth disease occasionally occurs in man; adults may be affected as the result of contact with diseased animals; the consumption of milk from affected cows is usually responsible for children being attacked. The virus passes through porcelain filters; it was the first ultra-microscopic virus to be discovered. Pasteurisation destroys the virus. In accordance with the Foot and Mouth Disease (Amendment) Order the M.O.H. is to be notified of every case or suspected case of foot and mouth disease in his district; he must see that milk from affected cows is not sold for human consumption.[1]

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[1] Savage, writing in 1912, gives details of thirteen outbreaks occurring in the British Isles between 1881–1904.

The characteristic feature of this highly infectious disease of cattle and other domestic animals is the eruption of vesicles on the mucous membrane of the mouth and on the skin between the toes and above the hoofs. The vesicles rupture, forming erosions and ulcerations accompanied by salivation, great tenderness of the affected parts, loss of appetite, lameness, emaciation, and in all but the mild cases diminution in the quantity of milk secreted. About the third day the disease is fully developed; the milk invariably contains inflammatory products of a very pronounced character, and the quantity of milk secreted is greatly reduced. In humans there is fever, sometimes with vomiting, painful swallowing, heat and dryness of the mouth, followed by an eruption of vesicles on the buccal mucous membrane and very rarely by similar ones on the fingers. These vesicles appear on the lips, gums, cheek, and edge of the tongue and are about the size of a pea. The vesicles soon rupture, leaving a small erosion which is soon covered by a thin crust under which the new formation of epithelium proceeds rapidly. The skin-eruption mostly appears on the hands, tips of the fingers, base of the nails, volar surfaces of the finger-tips, and more seldom on the toes and other parts of the body. Besides these local changes during the course of the disease there are occasionally observed headache, pain in the limbs, vertigo, abdominal cramps, vomiting, diarrhœa, and weakness. The disease is rarely fatal; it usually appears in a very mild form except in weakened children in whom an accompanying intestinal catarrh may lead to a fatal termination. The veterinary surgeons who have had considerable experience with this disease among animals regard the human affection as by no means uncommon in countries where foot and mouth disease prevails, but the disturbance of health is usually too slight for the patients to attend a medical man. In the classical outbreak in this country which took place at Dover in 1884, some four deaths occurred among 205 persons affected.

Diarrhœa—Although by no means common several outbreaks of diarrhœa have been ascribed as due to infection of milk. An example of such an outbreak is one occurring in 1923 in Aberdeen. The acute enteritis was accompanied by marked prostration and a rise of temperature which affected 110 persons after drinking milk from a certain farm where all the farmer's children had recently been suffering from acute enteritis and were looked after by his wife and sister who were also engaged in the production of milk. The nature of the organism was undiscoverable by ordinary laboratory methods; it was suggested that a filterable and ultra-microscopic virus might have been responsible.

The Reports of the Medical Officer of the Local Government Board for 1893 and for 1895–6 give account of occurrences of an "epidemic skin disease" in certain workhouse infirmaries. Copeman found reason for concluding that the disease had been distributed by "milk, but it was not possible to make exact inquiry as to the changes to which the milk . . . was subjected before being delivered to the inmates of the institution in question."

Butter was shown by Shirley Murphy to have been in all probability the infecting agent in an outbreak of diarrhœa which occurred in a large hospital. Typhoid bacilli will live in butter for a considerable time.[2] Tubercle bacilli have frequently been found in butter;

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[1] See Article 15 of Dairies, Cowsheds and Milkshops Order.

[2] Buick has found typhoid bacilli in butter 27 days, Washburn 60 days, after infection.

Schroeder and Cotton have found that these bacilli can retain their virulence for at least 160 days in salt butter when kept in a cellar without ice. Butter at times contains tyrotoxicon.

Cheese—Bacteriological examinations have suggested that organisms of the coli group producing powerful heat-resisting toxins have been responsible for some outbreaks; others have been due to an infection with B. paratyphosus B.

In 1922 in a small outbreak of food poisoning due to Wensleydale cheese the blood of the sufferers agglutinated bacilli belonging to the Salmonella group. Cheese imported from Canada gave rise to four outbreaks in the same year; the investigation showed a water-soluble toxin was present. Tyrotoxicon has been responsible for large outbreaks; Vaughan isolated this substance from cheese which caused the illness of some 300 persons in Michigan in 1883 and 1884. More recently in 1901 seventeen persons suffered in Finsbury after eating Dutch cheese from which tyrotoxicon was recovered. The effects produced by tyrotoxicon are in the main gastro-intestinal disturbance which may be accompanied by symptoms resembling those of atropin poisoning.

Ice-cream—Tyrotoxicon has similarly been found in several samples of poisonous ice-cream. In outbreaks of typhoid fever and Gärtner infections ice-cream and custard have served as the vehicle.

Potatoes have given rise to a considerable number of outbreaks of food poisoning. Although solanin has been suspected the amount of the alkaloid present in the potatoes implicated has been found to be less than in ordinary potatoes; bacterial activity is probably responsible.

PRESERVATION OF FOOD

From time immemorial it has been found necessary to preserve the food of seasons of plenty for times of scarcity. Modern civilisation requires that perishable food should be preserved so that it can be transported from its place of origin to the large centres of population. Drying and smoking, the use of common salt, sugar, vinegar and nitre are all methods sanctioned by custom which have not been shown to have given rise to harm.

In comparatively recent years canning, cold storage and chemical preservatives have been increasingly used. All these methods have the same end—the prevention of bacterial decomposition.

Canned (*tinned*) *Foods*—This process owes its origin to M. Appert, a Parisian confectioner who in 1804 found that food sealed hermetically in glass jars and placed for an hour in boiling water kept indefinitely. This method he improved on by sealing the vessels after the heating had driven out the air and its place had been taken by steam which on cooling created a vacuum. The only advances since have been the use of metal containers and the adoption of fractional sterilisation, *i.e.*, a second or even a third heating after intervals of 24 hours so as to kill any spores which have germinated. The tins should show concave collapsed ends tightly pressed against their contents ; bulging ends are evidence of the formation of gas (" blowing ") which is invariably due to the action of bacteria.

A second solder hole may have been made legitimately during the canning process and is by no means evidence that the tins have been vented to let out gases caused by bacterial decomposition and then resealed. In rusty tins the process may have gone so far as to cause perforation. Savage holds that while understerilisation is one cause of tins of meat becoming defective it is evident that the main cause is defects in the can. There are either defects in the quality of the material used for the tins allowing perforation, defects in the methods of sealing after filling or defects due to improper treatment subsequent to sterilisation.

Practically no harm results from the consumption of tinned food provided the food was sound before canning and that enough fresh food is eaten as well.

The source of outbreaks of food poisoning due to tinned foods could be more readily detected if the actual source and local place of canning of the product should be stamped on the tin to facilitate identification.

The amount of tin derived from the container increases with the length of such canning. Tin containers are preferable to glass in that they permit sterilisation of the contents to be more easily carried out, less breakage occurring at higher temperatures when metal is used. Any glass used should be free from lead, borax and fluorides.

Savage discusses the question as to whether vitamins are present in canned foods in his work on " Canned Foods in Relation to Health." He says (p. 99) :—

> " It is not possible to give a simple direct answer. Very many factors are concerned. We have to remember that the whole of our knowledge as to vitamins is quite recent, that these substances are present in only minute quantities, that they have never been isolated in a pure state, that the only methods available for their detection require considerable experience if judgment is to be sound and are liable to many fallacies.
>
> " We have in addition to remember that the methods of preparation of foods by canning are both complicated and variable and the changes induced may be considerable and are much more than merely the effect of the application of a particular degree of heat. In other words we have to take into consideration not only the degree of heat applied to the product but also its method and particularly its rate of application. The chemical changes cannot be ignored, such as changes in hydrogen ion concentration, oxidation, or colloidal changes. The factor of time since canning may be important as these vitamins are affected by storage and canned foods may be kept for years. Finally the quantitative factor is of essential importance and the fact that sufficient vitamins may be

left to prevent pathological effects does not prove that they may not be dangerously diminished.

"With all these variable and uncertain factors affecting the result, it is imperative that great caution be exercised in stating that any canned foods retain unimpaired the vitamins which they contained in the raw state.

"With our present knowledge it is a reasonable attitude to take up that the whole complex of changes which are necessary in canning foods are detrimental to their content in vitamins, that these changes are more marked the greater the manipulation generally but are especially affected by the oxidation allowed and the temperatures reached in processing. Of temperature influences the three most potent are the actual temperature reached, the time given at that temperature, and the rapidity with which it is attained.

"It is further evident that the three types of vitamins which are at present recognised are not equally affected by these adverse influences. The A type is comparatively heat stable and if the heat applied is not too high, is quickly applied and is not maintained for long, there may be no material diminution in the vitamin content. In actual practical conditions it has been found that these conditions are often fulfilled so that experimental results have shown comparatively slight reduction in this vitamin.

"As regards the B type the evidence is that this is more thermolabile, and with any considerable application of heat it is likely to be entirely destroyed or dangerously reduced. We do not yet know, however, how far this is influenced by oxidation, and Hopkins finds that when oxygen is rigorously excluded this vitamin also shows a very considerable resistance to heat. Vitamin C is still less resistant to heat and it is probably safe to assume that it is nearly completely absent in most canned foods."

Cold storage has the advantage of leaving the article in approximately its original condition. It is possible that each foodstuff has its optimum temperature, thus meat and poultry are best frozen, while the temperature of milk cannot be reduced to freezing point without injury. Experiments on eggs have shown that preservation does not depend upon a critical rate of cooling being exceeded but upon the rate of cooling falling within certain limits. When these are observed the changes which take place on thawing are reversed in thawing; when they are exceeded the changes are irreversible.

Although some bacteria grow and multiply at 0° C., cold produces a reduction in the number of bacteria including pathogenic bacilli present and many of those that at first survive eventually die.

The same is true of animal parasites. Trichinæ die at a temperature of $-15°$ C. or less in twenty days—the larvæ of Tænia saginata at $-9°$ C. or less in six days.

Chemical Preservatives are largely used because their addition is a simple and a cheap way of preserving food. The objections urged to their use are several. The preservative may be harmful to man in the amounts used. Even if agreement is reached that the preservative when present in a certain amount is harmless there is no certainty that this amount will not be exceeded, *e.g.*, by carelessness on the part of the person adding the preservative.

Again, if each of several articles consumed during the day contain an unknown amount of preservative it is possible that the consumer may take in a considerable and harmful amount of preservative during the day.

If it be admitted that the preservative is harmless to healthy adults it may be harmful to persons suffering from disease such as kidney disease or weak digestion or to young children; idiosyncrasy may also exist.

Substances which are foreign to the animal body are excreted as foreign substances by the kidneys; during their elimination they may work harm, especially if the kidney be defective or diseased.

Again a preservative harmless when taken on a single occasion may be harmful if consumed over long periods; especially is this likely to be the case if the substance be a cumulative poison, or the kidney be defective in excretory power.

Lastly, the addition of these preservatives affords opportunities for food to be collected, prepared or stored under conditions prejudicial to health, or may be used to hide lack of freshness or to mask the evidence of commencing decomposition or the inferiority of the article to which they are added.

Among the chemical preservatives frequently used are boric acid and borax, presumably because they are tasteless. Neither of these substances are normal constituents of the body or of food. There is abundant medical evidence to show that in an appreciable proportion of children and adults boric acid has caused serious toxic symptoms apart from any action on the digestive ferments.[1]

In addition Wiley's feeding experiments on a squad of healthy young men showed that even 7½ grains a day of boric acid or its equivalent of borax is too much for a normal adult; it produces diminution of appetite, fullness and uneasiness in the stomach and occasionally nausea, also dull and persistent headache; larger doses, 62–67 grains a day of boric acid or its equivalent of borax cause inability to work. Other experiments have shown that boric acid is injurious to kittens,[2] and that boric acid and borax retard digestion by calves.[3]

Harrington's experiments on feeding cats showed that borax administered over several months produced nephritis.[4]

Conflicting evidence is forthcoming; Tunnicliffe considered that his experiments showed that neither borax nor boric acid affected the health of the children under observation. Chittenden and Liebreich working independently added borax and boric acid to the food of dogs with the result that the digestion of the food was not perceptibly impaired and the animals gained in weight. In view, however, of the positive evidence of harm, the use of the substances cannot be regarded as free from danger.

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[1] See Thresh and Porter, "Preservatives in Food and Food Examination," p. 39.

[2] See Annett, "Lancet," Nov., 1899.

[3] Bulletin No. 86 Maryland Agricultural Experiment Station, Sept., 1902.

[4] See "Lancet," Sept. 17, 1904.

In regard to *salicylic acid*, idiosyncrasy plays a large part, individuals varying considerably as to their reaction to this substance. The signs of an overdose of salicylic acid are well known ; its long-continued use has caused loss of appetite, diarrhœa alternating with constipation, renal disturbance, skin eruptions and mental depression. Wiley's feeding experiments in 1905–7 showed that salicylic acid added to food even in small quantities could exert a similar harmful effect. When taken in food it acts at first as a stimulant, increasing the absorption and solubility of the food from the alimentary canal, it soon becomes a depressant tending to break down the tissues of the body more rapidly than they are built up. It has a tendency to diminish the weight of the body and to produce a feeling of slight discomfort and malaise.[1]

Sodium benzoate and benzoic acid—Directly opposite results have been obtained from feeding experiments on healthy individuals by Wiley, who found that the addition of sodium benzoate to food caused impairment of appetite, disturbance of digestion and other injurious effects and the U.S.A. Referee Board who found that moderate quantities over a period of four months caused no appreciable effect.

Benzoic acid is held to be harmless on the ground that it unites in the liver with glycocoll, one of the decomposition products of protein, to form hippuric acid, a normal constituent of urine.

Small amounts, *e.g.*, 0·1 per cent. of these substances are probably harmless.

Small quantities of *formaldehyde* have been shown by Halliburton [2] and others to delay the action of the digestive ferments, they also cause dyspepsia and other digestive disturbance in susceptible individuals.

Even in so dilute a solution as 1 in 5,000 it makes meat and fish tough.

Sulphites are often used by butchers, poultry dealers and brewers ; they act as an antiseptic and preserve the colour of the meat.

Even in minute quantities sulphites hinder the action of ferments and interfere with digestion. Nephritic changes were found by Harrington and extensive hæmorrhagic and inflammatory lesions by other observers in the organs of animals fed on food containing the quantities commonly used as a preservative. Its use is forbidden in Germany (1898) and the United States (1906).

The most important colouring matter added to food is copper sulphate, chiefly used for the greening of vegetables. The copper is held to combine with chlorophyll to form insoluble copper phyllocyanate, any remaining over combines with protein to form copper leguminate; if a large quantity is added free copper sulphate may remain.

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[1] See Bulletin No. 84, Part II, pp. 758–9, U.S.A. Bureau of Chemistry.

[2] "British Medical Journal," 1900, Vol. II, p. 1.

Copper leguminate is acted upon during gastric and pancreatic digestion and rendered soluble. The proportion of the copper sulphate absorbed is held by some to be as low as 40 per cent., by others as high as 90 per cent.

In addition to the astringent action of copper sulphate on the mucous membrane of the stomach causing contraction of blood-vessels which must be dilated for normal digestion, its inhibition of the action of the digestive ferments and its possible irritating effect on the kidneys, it would seem from American feeding experiments on healthy men that copper is retained in the liver and by analogy with the effects known to be produced by the retention of other heavy metals in the body it is inferred the retention of copper must be harmful.[1]

Tunnicliffe, a member of the Departmental Committee of 1899, considered that no harm would result from the addition to food of ½ grain of copper per pound (equivalent to 2 grains of crystallised copper sulphate) but that its presence should be declared on the label. Smaller quantities than this, however, have been shown to cause harm and its use should be prohibited as the Departmental Committee recommends; this prohibition is in force in Germany and U.S.A.

A summary of conclusions and recommendations of the departmental Committee on preservatives and colouring matters in food, 1924, follows:—

1. Preservatives should be prohibited in all articles of food and drink offered or exposed for sale whether manufactured in this country or imported, except that (*a*) Sulphur dioxide only should be permitted; (i) in sausages in amounts not exceeding 3 grains per pound; (ii) in jam in amounts not exceeding 0.3 grains per pound; (iii) in dried fruit in amounts not exceeding 7 grains per pound; (iv) in preserved (but not dried) whole fruit or fruit pulp in amounts not exceeding 5 grains per pound; (v) in beer and cider whether in bottle or in cask in amounts not exceeding 5 grains per gallon; (vi) in alcoholic wines, non-alcoholic wines and cordials, and fruit juices, sweetened or unsweetened, in amounts not exceeding 3 grains per pint. (*b*) Benzoic acid only should be permitted; (i) in coffee extract in amounts not exceeding 3 grains per pound; (ii) in non-alcoholic wines and cordials and sweetened and unsweetened fruit juices (as an alternative to sulphur dioxide) in amounts not exceeding 5 grains per pint; (iii) in sweetened mineral waters and in brewed ginger beer in amounts not exceeding 1 grain per pint. The method of estimating the foregoing preservatives should be prescribed by the Minister of Health.

2. The sale of any preparation as a food preservative or for use in such circumstances that it may be introduced into food should be declared illegal unless such preparation (*a*) bears a description clearly indicating its composition and strength; (*b*) is free from impurities and in particular contains not more than 1/100th part of

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[1] See "Report of Referee Board, U.S. Dept. of Agriculture," 1913 (No. 97).

1 grain of arsenic per pound or more than 1/7th part of 1 grain of lead per pound.

3. The nature and quantity of preservative present should be declared in a manner prescribed by the Minister of Health. Exceptions may be made, but this should not apply to sausages.

4. The employment of a copper salt to colour or preserve the colour of peas and other vegetables should be prohibited.

5. A schedule of non-injurious colouring matters should be issued by the Minister of Health.

FOOD POISONING

Food poisoning arises from two main causes, viz :—

(1) the contamination of foods by inorganic poisons (*e.g.*, arsenic, antimony, copper, lead) and

(2) bacterial contamination.

Arsenic—In November, 1900, Reynolds of Manchester suggested that arsenic contained in beer was the cause of an outbreak of arsenical poisoning in that city. The epidemic was not confined to Manchester, and Salford, but affected other districts in Lancashire, in Staffordshire, and elsewhere; some 6,000 persons were affected of whom at least 70 died.

The disease was characterised by peripheral neuritis with paralysis, wasting of muscles of the extremities, functional derangement of sensory nerves; herpes, erythema, pigmentations, and other skin affections also occurred. A Royal Commission appointed to inquire into the matter reported in 1901, " The epidemic of sickness has been traced to beer from particular breweries, the latter having been users of brewing sugars supplied by a single firm." In samples of glucose obtained from this firm, amounts of arsenic, as arsenious oxide, were found varying from ·008 to ·131 per cent. (·56 to 9·17 grains per pound); in samples of invert sugar arsenious oxide to the extent of ·02 and of ·062 per cent. (1·4 and 4·34 grains per pound) was found.

The implicated brewing sugars, it was ascertained, " became thus seriously contaminated by arsenic in course of manufacture, through the use of sulphuric acid supplied by a single firm of acid makers."

The amount of arsenic found in implicated specimens of beer was, in exceptional cases as high as 1½ grains per gallon (in one case 3 grains per gallon was detected), but, as a rule, the quantity of arsenic did not exceed 1, or ½, or ¼ of a grain per gallon or less.

Many of the sufferers were heavy drinkers of beer; but others had only taken quite moderate amounts.

Evidence was forthcoming showing that arsenic may gain access to beer—by way of brewing sugars (in cases in which the mineral acid employed in the manufacture of glucose from starch, or of " invert sugar " from cane sugar has been arsenical); by way of malt (if fuel which contains arsenic be employed, material quantities of arsenic may be deposited on malt in the process of malting, and so reach beer); and in other ways (by use of chemical substances employed for various purposes).

Shellac used as a varnish for tinplate containers and as a coating for sweets, contains arsenic and may contaminate food; glucose was suspected to be the vehicle conveying arsenic to sweets in a small outbreak of arsenical poisoning in Manchester in 1908. Insecticide solutions used for spraying fruit and vegetables often contain arsenic and are a possible source of danger. Arsenic has been found in dangerous quantities in acid calcium phosphates, one of the constituents of cream of tartar substitute used for making baking powder substitute; the poison was derived from sulphuric acid contaminated with arsenic used to prepare the acid calcium phosphate.

Food has been contaminated in course of transit by contact with leaking packages, *e.g.*, can of arsenical weed killer; in such cases the poisonous material is apt to be concentrated in food in the outer part of the package adjacent to the source of contamination and not fairly uniformly distributed as occurs when foods are contaminated during preparation or by the use of impure ingredients.

The Report of the Royal Commission on Arsenical Poisoning, 1901–3 (p. 50) states that as regards the proportions of arsenic in food which should constitute an offence under the Sale of Food and Drugs Acts, pending the establishment of official standards, the evidence we have received fully justifies us in pronouncing certain quantities of arsenic in beer and in other foods as liable to be deleterious and at the same time, capable of exclusion, with comparative ease, by the careful manufacturer. In our view it would be entirely proper that penalties should be imposed under the Sale of Food and Drugs Acts upon any vendor of beer or any other liquid food, or of any other liquid entering into the composition of food, if that liquid is shown by an adequate test to contain $\frac{1}{100}$th of a grain or more of arsenic in the gallon; and with regard to solid food —no matter whether it is habitually consumed in large or small quantities, or whether it is taken by itself (like golden syrup) or mixed with water or other substances (like chicory)—if the substance is shown by an adequate test to contain $\frac{1}{100}$th grain of arsenic or more in the pound.

The "British Pharmacopœia," 1914 (p. 505), gives the limit of arsenic permissible in various drugs; it ranges from 0·2 parts per million in Liquor Magnesii Bicarbonatis to 1,000 in Antimonium Sulphuratum.

Lead—Beer has, in some instances, been found to take up lead from the vessels in which it has been kept, and it has been noted that persons who habitually consumed beer, which had stood overnight in contact with lead and had thus become polluted, were specially liable to be attacked.

In 1922 at least ninety-three definite cases of lead poisoning (comprising only three women) were notified to a brewery company in Middlesex, among beer-drinkers, the beer having dissolved a substantial proportion of lead (about one grain per gallon) from the enamel used to line the tanks to store beer in public houses. One of these patients died.

“ Devonshire ” colic was shown to be due to drinking cider which formerly was allowed to come into contact with lead vats in the course of manufacture. Recently an outbreak of lead colic in Devonshire was traced to the drinking of cider drawn through lead pipes which had been tin washed.

The “ British Pharmacopœia,” 1914 (p. 498), gives the limit of ead permissible in various drugs : it ranges from 0·5 parts per million n Liquor Magnesii Bicarbonatis to 25 in Acidum Boricum.

Copper poisoning has occurred from eating food cooked in copper utensils.[1] Vomiting has occurred after drinking soda water from soda fountains in Manchester : the instrument used contained a copper cylinder lined with tin. Copper was found in green oysters (about 0·02 grains of cupric oxide per oyster) obtained from certain Cornish beds ; a metallic taste was present.

Tin is much used as a coating to sheets of iron made into “ tins.” The tin is especially taken up by foods containing acids such as meat extracts and acid fruits and vegetables including peaches, pears, apricots, pineapples, asparagus, and tomatoes ; the solid part of the contents may contain more tin than the liquid part.

Heavy tin coatings are no better than lighter coatings : solder gaining access to the interior of the vessel causes a more serious contamination of the contents with tin (and lead). Acute poisoning has been shown to have been set up in adults who have taken at a single meal about 2 grains of tin ; it is probable, however, that 1 grain may be harmful. No evidence of the existence of chronic poisoning rom this source is forthcoming.[2] The action of the contents on the tinplate is prevented to a considerable extent by coating the inner surface with a suitable gum or varnish.

Zinc poisoning—The use of galvanised iron vessels for cooking purposes has given rise to zinc poisoning within a few minutes of consumption of the food ; 200 out of 400 persons served with apples tewed in a galvanised iron vessel complained of dizziness, nausea or vomiting, colic or diarrhœa and a feeling of tightness in the throat ; all were well next day. Jam made at Ipswich in a galvanised iron pan was found to be contaminated with zinc to a poisonous extent. Considerable amounts of zinc and copper were found in certain oysters purchased in Liverpool in 1913–14 ; in such contaminations any metallic taste and colour may be absent.

Food Poisoning of Bacterial Origin

The considerable majority of food poisoning outbreaks of *bacterial origin* are caused by the consumption of food infected with one of the

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[1] See “ British Medical Journal,” 1898, Nov. 12, p. 1532.

[2] See L.G.B. Reports of Inspector of Foods, No. 7, “ On the presence of tin n certain canned foods, 1908.”

Gärtner (Salmonella) group of bacilli. Savage [1] includes under the true Gärtner bacilli three types :—

(*a*) B. enteritidis comprising many of the Gärtner bacilli isolated from food poisoning outbreaks, B. ærtrycke, several of the rat viruses (such as Danysz bacillus) and some strains of B. typhimurium.

(*b*) B. paratyphosus B, the organism causing para-typhoid fever B ; also found in the human intestine in carrier cases.

(*c*) B. suipestifer includes a number of food poisoning bacilli ; some B. typhimurium strains and probably B. psittacosis. The strains isolated from cases of swine fever (hog cholera) belong to this group. The toxic products of the growth of these organisms can resist the degree of heat used in cooking. The source of the organism has in rare instances been traced more or less clearly to diseased conditions in the animal cooked for food. The incubation period in Savage's series of outbreaks in this country has varied from half an hour to forty hours or even longer, depending, it is suggested, on whether toxin is already present or the bacilli have to develop the toxin, and the amount of food (and so toxin) consumed.

The onset is sudden, the symptoms being those of severe gastro-intestinal irritation frequently accompanied or followed by nervous symptoms. Diarrhœa and abdominal pain are almost invariably, and vomiting usually, present. Prostration, marked and often persistent, and collapse occur in severe attacks. A moderate rise of temperature is present in the early stages of the disease. Numbness and cramps in the limbs have been prominent symptoms in some outbreaks. Herpes, erythematous and urticarial rashes have been recorded. The illness is usually over in two or three days but attacks have lasted several weeks. A few instances of spread of infection from one patient to another have been recorded. Persons of either sex or of any age are apparently equally susceptible. Although not infrequently all of those who consume the infected food become ill instances are recorded in which some have remained well.

The case mortality in Savage's series is low—94 deaths among 6,190 cases.

The outbreaks are far more prevalent in the hotter months of the year. It is unfortunately necessary to emphasise the fact that the food giving rise to the poison is not noticeably altered in appearance, taste, or smell. In 90 out of 112 British outbreaks a meat food was incriminated, usually prepared, *i.e.*, tinned, made into pies, brawn or potted rather than ordinary joints or cuts of meat cooked once at home; mutton is very rarely at fault. The temperature reached by these prepared articles during cooking is often insufficient to kill typhoid and Gärtner bacilli although these are destroyed at comparatively low temperatures.

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[1] See "Food Poisoning and Food Infections," Savage, p. 63. In the report (Medical Research Council, Special Report Series No. 91) of Savage and Bruce White on bacteria of the Salmonella group, they refer to ten main types. The commonest causes of food poisoning outbreaks are B. ærtrycke and B. enteritidis. B. ærtrycke produces disease in cows, calves and rats, B. enteritidis is a widespread cause of enteritis in mice, guinea-pigs and birds ; it is found occasionally in pigs and calves but not often in rats. B. suipestifer to cause food poisoning requires special conditions such as massive infection and is consequently less often responsible. It should be noted that the toxins of the Salmonella group possess a high degree of thermo-stability and can produce their effects after the destruction of the organisms themselves in the processes of canning food.

Ice-cream has been the vehicle of Salmonella infection.

On inspection it has often been found that the food was prepared under conditions exposing it to fæcal contamination from animal carcasses, guts, flies or dust.[1] Gärtner bacilli have been recovered from flies (both from the external surface and intestine) under natural conditions. Rats and mice are not infrequently the vehicle of nfection. The existence of a Gärtner infection can be determined by an examination of the agglutinating properties of the patient, but the agglutinins are not formed till several days after the onset of the illness. The fæces of patients in the acute stage and any unconsumed portions of the suspected food should be examined bacteriologically.

Botulism—Until the Loch Maree outbreak[2] in 1922, where eight persons ate sandwiches made from a pot of wild duck paste and all died, botulism was not believed to occur in the United Kingdom. Although the disease has been known clinically in Germany since 1735 its bacterial origin was not proved until 1895, when Van Ermengem isolated a bacillus from a fatal case and from the ham the consumption of which had given rise to about thirty cases of botulism.

The bacillus was given the name of B. botulinus (now called Clostridium botulinum); it forms spores. Van Ermengem believed it to be a saprophyte which when it grows in food under anærobic conditions produces a toxin, but it has recently been shown that toxin can be produced in the bodies of living guinea-pigs and milk. Two distinct strains, A. and B., have been distinguished; they produce specific and heterologous toxins and anti-toxins.

Not only ham and sausages, but other meats and fish have been at fault; the disease has followed the consumption of home-canned vegetables or fruit. In almost all cases the food containing the toxins of C. botulinum has been obtrusively unsound.

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[1] An outbreak at a Brighton hospital, reported on p. 75 of the "Annual Report of the C.M.O. to the L.G.B., 1917–8," and also in the "Journal of Hygiene" was attributed by Savage and Forbes to the contamination of the fish by a "carrier." See also p. 43, "Food Poisoning," M.R.C. Spec. Report Series, No. 92.

[2] For Savage's comments, see p. 77, "Canned Foods in Relation to Health."

The symptoms have appeared within 6 hours of eating the infected food, the usual period of incubation is 12–24 hours, it may be 36–48 hours or so long as 6 days. The symptoms are almost entirely nervous in character, vomiting and diarrhœa may occur but are usually slight and transitory; constipation due to paralysis of peristalsis is the rule. The temperature is generally subnormal.

Disturbances of vision occur early, amaurosis is followed by partial or complete paralysis of accommodation, ptosis and diplopia, the extrinsic and the intrinsic muscles of the eye being affected. The patients complain of difficulty of swallowing and a sensation of contraction of the throat. The progressive muscular weakness observed in severe cases simulates paralysis; death is due primarily to respiratory failure.

The thermal death point of the spore suspended in water, *i.e.*, the temperature required for the destruction of the spore in tinned foods, has been found to be 5 hours at 100° C., 40 minutes at 105° C., 15 minutes at 110° C., and 6 minutes at 120° C.; toxin will not form in brine containing over 8 per cent. of sodium chloride.

Thorough cooking will destroy any toxin of this bacillus—the most resistant strain was destroyed on exposure to 80° C. for 2 minutes, 72° C. for 10 minutes and 65° C. for 85 minutes, but as the toxin may re-form, the cooking should be within a short time of serving.

The anti-toxin to be of any avail must be given early; its utility is doubtful if symptoms have commenced.

It has been held that food poisoning attacks are caused by massive infection with fæcal and other bacilli, but this is negatived by such considerations as the large extent of fæcal pollution of food and the small number of cases of food poisoning; the absence of special incidence of poisoning followed the consumption of a food especially the subject of fæcal contamination such as milk; also by the growing number of records of outbreaks where full investigation has been possible and a specific organism found to be responsible.

That the attacks are due to the consumption of food in a state of incipient or developed putrefaction may be true of individual outbreaks, but this is not to say they are caused by ptomaine poisoning.

Ptomaines are late degradation products of the protein molecule elaborated by many bacteria, most of which are nonpathogenic. These ptomaines are only produced at a stage of decomposition when the food is far too offensive to eat.

Included among the ptomaines are muscarin obtained from poisonous mushrooms, an extremely toxic substance, and mytilotoxin obtained by Brieger from toxic mussels and held by him to produce all the effects characteristic of mussel poisoning.

Vegetable Foods[1] are the main source from which carbohydrate is obtained; very little fat is derived from them (oats and maize contain a considerable quantity of fat, as also do some nuts; olive oil, moreover, is an instance of a vegetable fat, but fat as a rule s obtained from animal foods). Vegetables contain protein in the form of gluten, the substance produced when the globulin and albumose of wheat flour are acted upon by water; legumin and conglutin —substances derived from the proteins of the seeds of the leguminosæ —may also be present.

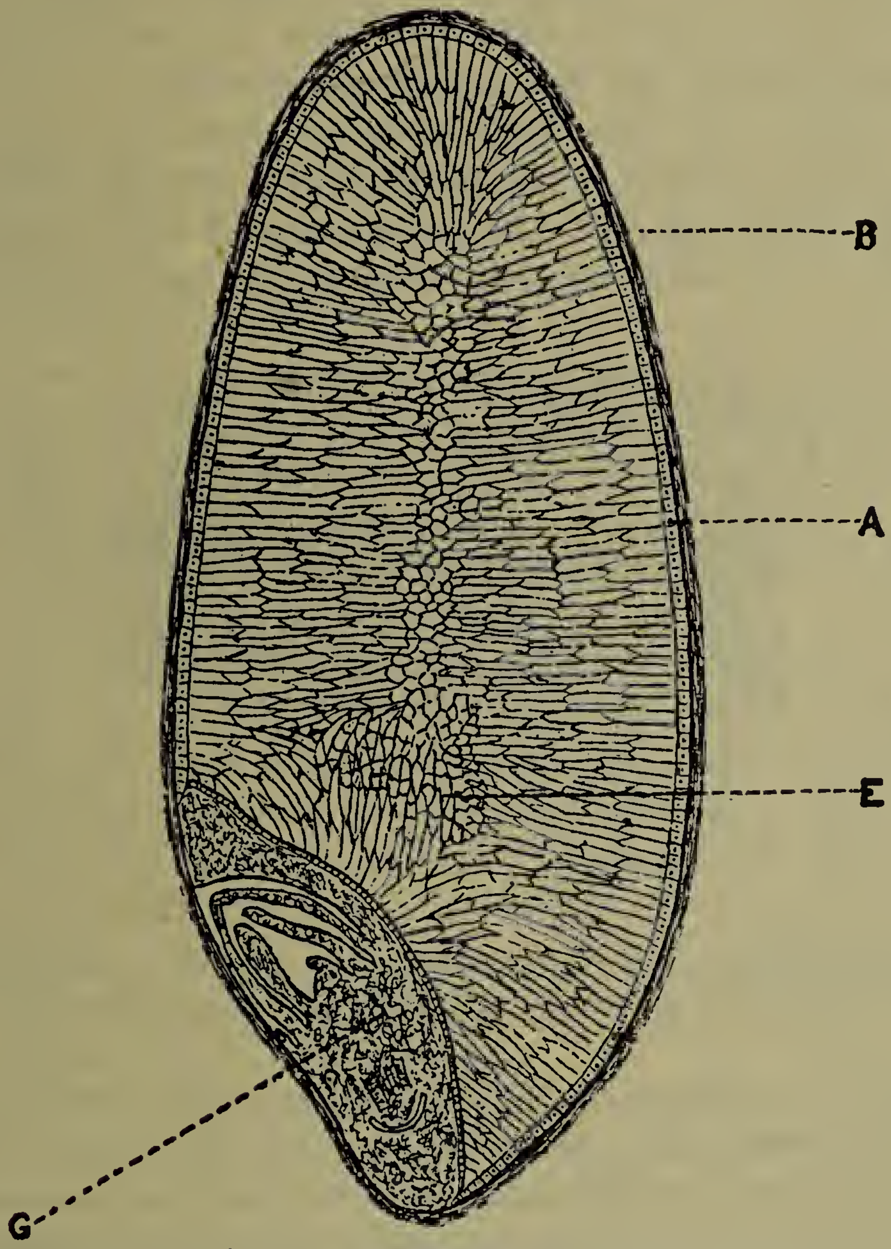

FIG. 33.—Diagrammatic longitudinal section through a wheat grain. B, pericarp with testa and nucellus forming the branny envelope of the grain; A, aleurone cell layer of endosperm; E, parenchymatous cells of endosperm; G, embryo or germ.

During the milling of wheat the outer coats are often removed, the germ escapes and the remaining inner portions are then converted into ordinary white flour. Other flours contain a certain amount of "offal." This includes: "bran," the pericarp and aleurone layer

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[1] The problem of vegetarianism is discussed by Hutchison in "Food and Principles of Dietetics," fifth edition, 1923, p. 192, where several valuable references are given.

(the outer layer of the endosperm) with some more adhering cells of the more internal part of the endosperm; "pollard" bran in a finer state of division; germ or wheat embryo fluff or fibre, the cellulose walls of the parenchymatous endosperm cells; and "sharps or middlings," mixtures of the finely divided branny particles, fluff and fibre and fragments of germ. The bran contains more protein, vitamin B and cellulose than the rest of the endosperm. The germ, however, is the richer source of vitamin B; the germ, weight for weight, is five times as potent in the case of wheat and ten times in the case of rice than the bran for the cure of polyneuritis.

This separation of the outer coats of the wheat grain generally somewhat lowers the percentage of protein and more distinctly lowers that of salts and vitamin; the percentage of carbohydrate, on the other hand, is increased. The bran of wheat contains much cellulose which cannot be digested and is moreover said to interfere with the absorption of food which is digestible; cellulose acts as an irritant stimulating peristaltic movement and for this reason some prefer it, and others if they eat brown bread suffer from looseness of the bowels. By various processes it has been sought by removing a portion of the bran and finely grinding the rest of the grain to lessen the irritating property of the bran, and thus to include more of the parts of the grain in making flour. Such "wholemeal" flour as a rule yields a somewhat larger percentage of protein and salts than ordinary flour does, but obviously contains more cellulose.[1]

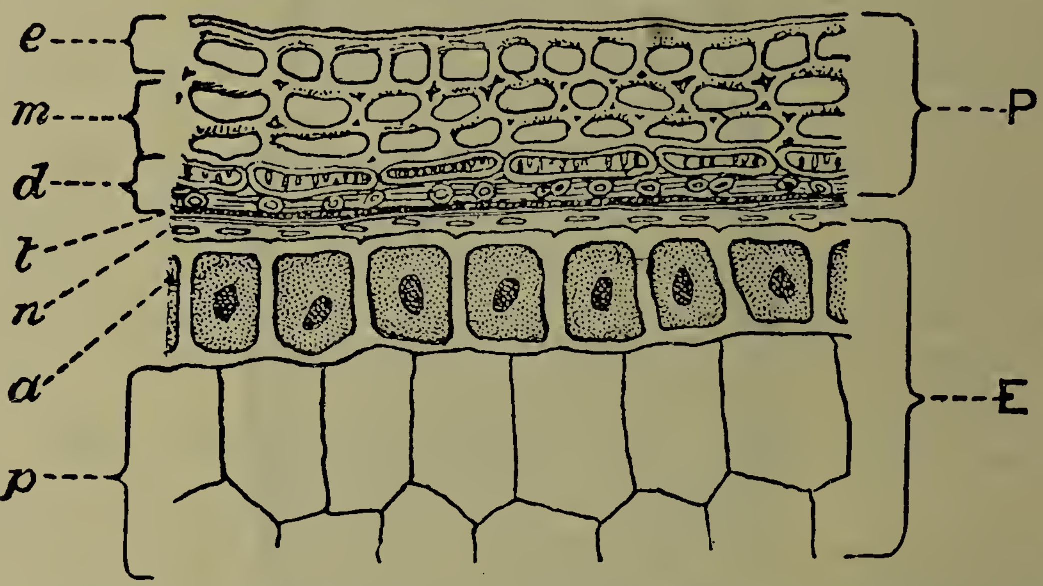

FIG. 34.—Cross section through branny envelope and outer portion of the endosperm of the grain × 160. P, pericarp consisting of *e*, epicarp, *m*, mesocarp, and *d*, endocarp. E, endosperm, consisting of *a*, layer of aleurone cells, and *p*, parenchymatous cells; *t*, testa, *n*, nucellus.

Extensive experiments instituted by the Food (War) Committee of the Royal Society on the digestion of different kinds of bread by human beings yielded results much more favourable to bread approximating to the "wholemeal" type than early observations would have led us to expect; the Committee found that during the use of bread made from 80 per cent. ("standard") flour which included the germ, 96·14 per cent. of the energy content in the diet was extracted for nutriment; with 90 per cent. bread 94·5 was extracted.[1] In germ flour the powdered germ (usually cooked) is added to increase the protein content of flour.

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[1] See Hamill's "Report to L.G.B." (1911) on the nutritive value of bread made from different varieties, especially pp. 4, 5, 11, 12 and 49; also Hutchinson, *loc. cit.*, p. 217.

The edible pulses (peas, beans, etc.) contain some 20 to 25 per cent. of protein, *i.e.*, even more than meat, but the vegetable protein is found to be less digestible than that of flesh. These pulses are among the chief sources of Vitamin B. Certain "oily seeds," the walnut, hazelnut, almond, peanut, etc., contain almost as much protein as the pea and bean and yield a large percentage of fat; they are not however easily digested.

The most important carbohydrate of vegetable foods is starch; sugars, however, occur, *e.g.*, cane sugar in the sugar-cane and grape-sugar in ripe fruit; dextrin is present in gums, and indeed is generally found in small amount in association with starch.

Alum and other adulterants may be looked for if the amount of ash exceeds 2 per cent. of the flour.

Pure bread may contain a small amount of alumina, equivalent to as much as 6 to 10 grains of alum in the 4 lb. loaf. Alum enters into the composition of some baking powders, and is also added to inferior bread, with a view to checking fermentative action; this form of adulteration is, however, rarely practised at the present time. It was formerly quite common to find the equivalent of 40 grains of alum, or even more, in the 4 lb. loaf, and when administered in such quantities dyspepsia and constipation were found to be associated with the consumption of the bread.

At the present day attention is directed rather to "improvers" such as acid calcium phosphate and potassium persulphate added to flour to increase the size of the loaf produced. The harmfulness of these substances is still under discussion.

The presence of various fungi can sometimes be detected on microscopic examination of flour. *Ustilago carbo* (smut) forms a black dusty powder in corn grains; the spores are smooth, spherical, and light brown in colour. *Tilletia caries* (canker) appears as a moist black powder; the spores are globular, with net-like ridges. *Puccinia graminis* present characteristic teleutospores. *Mucor mucedo*, *Penicillium* and *Aspergillus* may also be found in decomposing flour. The *Acarus farinæ* is sometimes found in flour, and the weevil, *Calandra granaria*, and the larvæ of other insects may at times be detected. The "ear cockle" (*Vibrio tritici*) is a minute, worm-like parasite, sometimes found in damp wheat. Ergotism, a condition accompanied by diarrhœa, vomiting and in some instances loss of sensation with paralysis and gangrene of the extremities, was of common occurrence in the Middle Ages, and more particularly on the Continent, as a result of eating black bread made from rye contaminated with ergot. The sclerotium or permanent mycelium known as ergot, forms dark, horn-like growths, which project beyond the rye grains. If the dark growth be removed and placed under favourable conditions it sprouts forming whitish shoots, terminating in globular heads of a purple colour. This growth is termed *Claviceps purpurea*, and the clubbed head is found on section to present the appearance shown in Fig. 37. At its margin are numerous flask-shaped perithecia, opening externally, each of which contains many fine transparent bladders, packed with needle-like spores. The spores when ripe are discharged, and if they obtain access to the flowering rye, the sclerotium (or ergot) is developed in it. Ergotism is of rare occurrence at the present time; the ergot is carefully collected when it is found, as its value as a drug is considerable. By sowing only

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[1] Spriggs and Weir ("Lancet," November 10) obtained similar results.

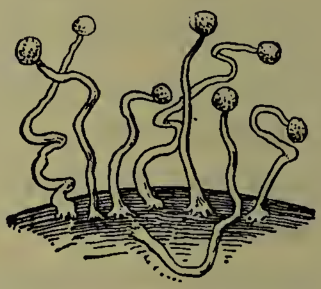

Fig. 36.—*Claviceps purpurea.*

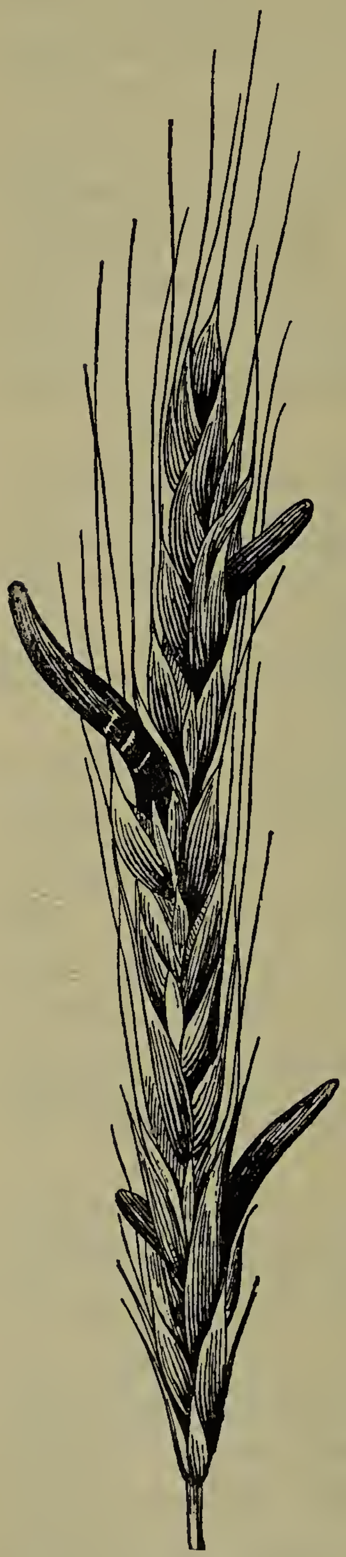

Fig. 35.
Spike of Ergotised Rye.

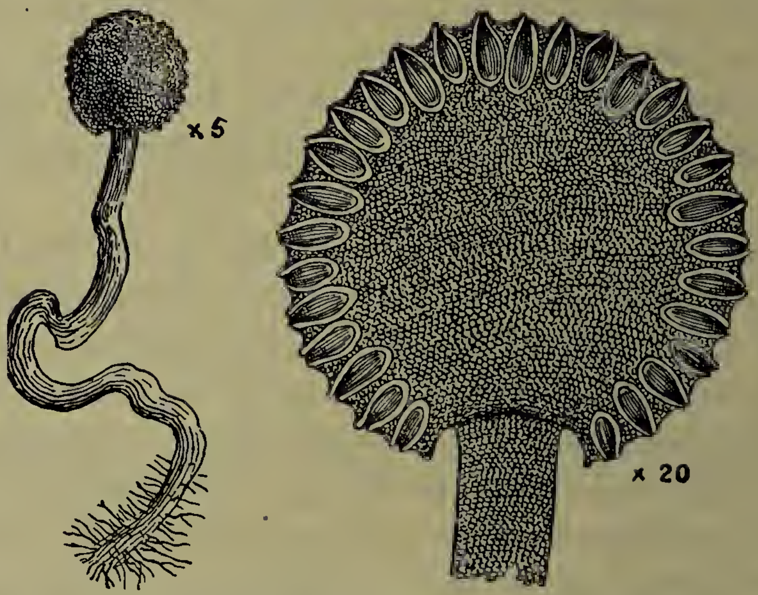

Fig. 37.—Clubbed heads of Claviceps purpurea, magnified. One head cut through longitudinally.

seed free from sclerotia rye can be raised free from sclerotia. A case of gangrene suspected of being due to ergotism was reported in Liverpool in 1922; the patient consumed a good deal of bread made of wheat meal and flour derived from rye grown in the neighbourhood.

Lathyrism or vetch poisoning is a rare chronic nervous disorder affecting men especially and due to the habitual use of the peas of certain species of Lathyrus. It occurs especially in India, also in Italy, France and Algeria.

Corn cockle (Agrostemma githago) in flour and bread has caused poisoning in France; the injurious effects are due to the presence of sapotoxin.

Mushroom poisoning is usually due to the eating of Amanita muscaria (fly fungus) or Amanita phalloides (death cup) but there are probably in all not less than twenty-two poisonous species in this country. The poison is not destroyed by cooking.

The symptoms are usually both gastro-intestinal and nervous in type; either set, however, may be present alone. Nausea, vomiting, diarrhœa with great thirst and prostration are often accompanied by muscular twitchings which may go on to convulsions, disorders of vision, somnolence and coma.

ALCOHOLIC BEVERAGES

Beer contains about 2·8 (mild ale original gravity 1016·5) to 11·1 per cent. (pale or bitter ale original gravity 1060·2) of alcohol.

Malt beers are made by inducing yeast-fermentation of sugar derived from the starch of grain, by the " malting " process. Non-malt beers are obtained by fermenting glucose, and allied substances, obtained by the action of sulphuric acid upon starch.

Wines contain from 9·2 per cent. of alcohol[1] (red Bordeaux), up to as much as 17 per cent. (port). Natural wines made by fermenting grape juice do not as a rule yield more than 12 per cent.; the wines with a higher percentage of alcohol are usually fortified by addition of spirit. British fermented wines may contain 20 to 28 per cent. of proof spirit without being so fortified.[2]

Wines contain varying amounts of sugar; vegetable acids are also present.

Spirits are manufactured by the process of distillation: in the case of brandy, fermented grape juice is used; in that of whisky, malted grain; in that of gin, malt with addition of certain flavouring substances (juniper berries, etc.); and in that of rum, molasses is employed.

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[1] By weight, see Appendix 4, " Alcohol, its action on the human organism " (2nd edition), H.M. Stationery Office.

[2] See also pp. 33–57, Ministry of Health Report on the composition of commoner British wines and cordials (Hancock).

By the Licensing Act, 1921, sec. 10, whisky, brandy, rum and gin must not be reduced by the addition of water so as to be more than 35 degrees under proof [1] (30·8 per cent by weight and 37·1 by volume of alcohol) without notice to the purchaser. Their chief ingredient is ethyl alcohol; variable amounts of the higher alcohols, compound ethers, and empyreumatic bodies, such as the substance known as "furfurol," may be also present. Some of the harmful effects of alcohol are probably attributed to such "by-products." The quantity of "fusel oil" (the name given to the group of higher alcohols) should not exceed ·02 per cent. Furfurol, present in some kinds of whisky to the extent of about ·005 per cent., is said to be specially deleterious, but its amount diminishes as the spirit "mellows" on keeping.

It is said that in moderation alcohol may be taken without ill effect, and the equivalent of 1 oz. of pure alcohol daily, is usually given as being the amount which should not be exceeded. Individual susceptibility, however, plays a considerable part in the matter, as in most persons of unstable nervous system and certainly in most young persons this quantity of alcohol is productive of harm.

The Advisory Committee appointed by the Central Control Board (Liquor Traffic) to consider the physiological action of alcohol formulated as its principal conclusions:—The main action of alcohol (apart from the effects of its continued excessive use) is confined to the nervous system; alcohol is narcotic rather than stimulant in action; its nutritional value is strictly limited; its habitual use as an aid to work is physiologically unsound; and the ordinary use of alcohol should not only be moderate, but should also be limited to the consumption of beverages of adequate dilution, taken at sufficient intervals of time to prevent a persistent deleterious action on the tissues.

The abuse of alcohol is productive of degenerative changes of the stomach, liver, and nervous tissues, and causes diminished power of resistance to certain forms of acute disease, particularly to pneumonia, tuberculosis and septic poisoning; the ability to withstand intense cold is also found to be diminished by the use of alcohol.

The question as to how far alcohol *per se* is operative in causing degenerative kidney change has been much debated; the relationship of the various beverages which contain alcohol to gout is also a subject on which there have been differences of opinion. Beer is said to be a great "gout producer." Beer drinkers tend to become obese, and it may be noted that beer, owing probably in the main to the "lupulin" it contains, acts as a depressant upon the nervous system.

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[1] Proof spirit is a mixture of 49·24 per cent. of alcohol by weight and 57·06 per cent. by volume with water. Thirty-five degrees under proof means that 100 volumes only contain as much alcohol as 65 volumes of proof spirit. The Excise Authorities take no concern in drinks containing less than 2 per cent. of proof spirit.

The conclusions reached by the Committee mentioned above with regard to *longevity* in relation to the consumption of alcohol were :—

(i) That the death-rate is lower and the expectation of life longer in the section of an Insurance Society admitting only total abstainers from alcohol than in the section admitting those who are not abstainers from alcohol.

(ii) That the statistics of mortality are more favourable for abstainers than are the returns for other societies making no such distinctions, and which issue policies chiefly to persons of a more prosperous social class.

(iii) That Friendly Society data are concordant with those of the Life Insurance Offices in this respect.

(iv) That the official statistics issued by the Registrar-General indicate an exceptionally heavy mortality among persons occupied in the liquor trade.

It does not follow from these conclusions that a consistently moderate use of alcoholic beverages shortens life, since we cannot sort out from the data brought into comparison those instances in which the habitual abuse of alcohol produces disease or death, or in which accidental abuse has a like consequence, nor can we exclude many other social factors operating for or against longevity.

It has not yet been proved that the moderate use of alcohol has any effect on the length of life.

If the definition of food include substances which can serve as fuel but are only available for immediate use, alcohol can be termed a food ; it can help to maintain the body's fuel reserve by reducing the need for drafts upon it, and by allowing fats and carbohydrates to be used for its replenishment. The stronger beers, *e.g.*, those of original gravity 1055, owe rather more than half their food value to contained alcohol, the remainder being provided by the dextrin and sugar present. Such beverages however cannot be used as a large element in the working diet without danger of inducing such bodily disorders as may be incurred through the constant exposure of the tissues to the action of alcohol.

The immediate ill-effects attendant upon immoderate indulgence in alcohol are sufficiently apparent ; the extent to which its habitual use in excess, but to a degree short of causing complete loss of control over the higher nerve centres (the coma and delirium of the drunkard) is responsible for degenerative changes in the brain is not yet definitely determined ; the present view is that no visible structural change occurs. In alcoholic peripheral neuritis degenerative changes have been found in the fibres of the nerves of the limb and also not infrequently in the related cells of the spinal cord. Even when full allowance is made for the large number of instances in which alcoholic indulgence is only a symptom of underlying mental disorder it remains true that alcoholism is the principal cause of a serious amount of insanity. Not only does it give rise to alcoholic delirium (*delirium tremens*), transient mania (*mania a potu*), acute alcoholic hallucinosis and polyneurotic psychosis (Korsakov's syndrome) but many other types of mental disease result from habitual intemperance. Small doses of alcohol lead to a relaxation of social conventions, the sexual instinct becomes less under control, self-criticism is in abeyance, in pathological states there are delusions of suspicion which may end in homicide—three-fifths of the crimes of violence are due to alcohol.

Alcohol is classed with lead and syphilis as one of the three racial poisons. Stockard's series of experiments on guinea-pigs showed that the offspring of alcoholised animals in comparison with the young of control animals in comparison of the same stock were conspicuously inferior in strength and vitality and in many instances presented gross abnormalities of organism. Further experiments are necessary before this wide-reaching conclusion can be considered proved, especially in view of the fact that these conclusions are not supported by R. Pearl and possibly other observers. Pearl's experimental evidence would appear to show that alcohol has a selective effect on the germ cells attacking the weaker elements, so that although the offspring of alcoholised fowls are fewer in number, being derived from the stronger element they are better animals.

That grave and widespread social evil follows in the train of excessive consumption of alcoholic beverages is common knowledge.

CHAPTER V

THE COLLECTION, REMOVAL, AND DISPOSAL OF REFUSE

THE problems connected with the collection, removal, and disposal of the refuse of communities have received a great deal of attention in recent years: of late there has been a growing tendency to insist upon a higher standard in such matters on general grounds—the importance attached to cleanliness, and to the prevention of offence to the eyes and nose, being now far greater than it was a century ago. Added to this the public now increasingly recognises the danger to health which results from accumulations of filth and from the adoption of faulty methods in connection with refuse disposal.

The nature of the solution of the problems in question depends, to a large extent, upon the character of the material to be dealt with. Refuse matters may be roughly divided into house refuse (ashes and vegetable and animal material), various kinds of animal refuse (*e.g.*, those associated with the keeping and the slaughtering of animals, and with the utilisation of waste animal products), slops and liquid refuse, and human excreta.

I—HOUSE REFUSE

The composition of ordinary London house refuse has been found to be as follows:—

Material.	Amount in 100 lbs. of Refuse.
Coal	·35
Coke	·15
Breeze and cinder	25·55
Ash	47·00
Dust and dirt	9·75
Paper, straw, fibrous material and vegetable matter .	13·15
Rags	·40
Bones and offal	·37
Bottles	·48
Glass	·37
Crockery	1·72
Metals	·68
	99·97

Both the collection and disposal of these materials were formerly almost exclusively in the hands of contractors, who carted away the dust, caused it to be sorted, sifted, and separated into "hard core" (broken crockery, brickbats, glass, old shoes, bits of rag, etc.), "soft core" (vegetable and animal refuse), and "breeze" and ashes. The sorted materials were sold for various purposes, and whatever could not be disposed of was deposited upon land with the object either of raising the natural level of the ground for building purposes, or of replacing gravel or sand which had been previously excavated from the site. In the neighbourhood of towns the combustible materials obtained from the refuse were, as a rule, utilised for heating brick-kilns.

Much annoyance was experienced under this system, in connection both with the collection and the disposal of the refuse. The infrequency of the scavengers' visits made it necessary to employ large brick or wooden receptacles for the purpose of storage, and the huge accumulations of material collected in these receptacles were apt to give rise to considerable nuisance. It is now usual to insist, in towns, upon the provision of bins of non-absorbent material, of limited capacity, and furnished with covers so as to prevent rain and moisture obtaining access to their contents. These bins should be emptied at least twice a week, and in some places daily removal is insisted upon; in summer time, especially, frequent removal of the refuse is particularly necessary. Much can be done by the householder in the direction of preventing offensive odours arising from the refuse, if a certain amount of care is exercised in the selection of the materials deposited in the pail; moist vegetable and animal matter should be burnt instead of being allowed to undergo decomposition in the dust receptacle. Nuisance associated with the removal of refuse can, moreover, be reduced to a considerable extent by the use of carts specially constructed for the purpose, provided with covers to keep out the rain and prevent dust being blown about; they must be loaded in such a way as to avoid the scattering of dust on passers-by.

Of recent years attempts have been made to reduce the bulk of the collected house refuse and to utilise various portions. After the removal of tins and other large articles the refuse is pulverised or crushed in machines and its bulk largely reduced, thus saving expense in transport to the dump; sometimes the pulverised material can be sold to farmers as manure.

More elaborate methods are employed by some local authorities in connection with salvage. Plants are erected to screen and grade the refuse, the following articles being separated: dust, fine cinder, large cinder, tins, rags, bones, glass and paper. The cinders freed from dust and débris by a patent washer are valuable fuel; the tins after passing through a detinning furnace are pressed into bales and sold. The rags can be sterilised and washed by suitable plant; paper is compressed into bales and re-pulped by paper manufacturers. The portion of the refuse passing through the screen can be sold as fuel for brick-kilns. The unusable refuse is either burnt in a destructor or removed to a dump, it may be, after preliminary pulverisation.

As regards subsequent treatment of the refuse, much of it is dumped on land (80 per cent. of London refuse). Complaints are received from time to time by persons living in the neighbourhood of contractors' yards. Nuisance has been continually complained of in connection with the removal of the material by barge or by rail; railway wagons conveying refuse now, however, are required to be covered. A serious difficulty latterly experienced in some districts has been the occasional complete breakdown of arrangements owing to transport troubles and the consequent accumulation of large quantities of decomposing refuse at depôts. Rural authorities strongly object to land in their areas being used for dumping crude refuse, especially when there is no organised method of covering the top surface with suitable material and no attempt is made to bring the land back into cultivation, and there is consequently a continual risk of nuisance being created by fermentation and the dump becoming a breeding ground for flies and rats.

To prevent nuisances from fire, rats, flies or smells arising from refuse tips the chief precautions are that the refuse shall be deposited in shallow layers, not exceeding 6 feet as a rule, and that each layer shall be promptly covered with 9 inches of earth or other suitable material. Experience has shown that low-lying land subject to floods and poor land can by such means be converted into arable land.

These drawbacks of the "dumping" system led to experiment being made as to the practicability of disposing of house dust by burning; and during recent years various types of "destructor furnace" have been invented, some of which dispose of the refuse without causing nuisance. Not only is this the case, but, in a few instances, it has been found possible to utilise the heat developed in the furnaces for generating steam, and thus to obtain power for driving machinery, in connection with electric lighting or other installations.

The appliances used are either "low temperature" or "high temperature" destructors. In the former, in order to prevent nuisance, a "cremator" is sometimes employed through which the fumes from the burning refuse are passed, before being allowed to escape into the outer air. In the high temperature destructor, the principle adopted has been to place the exits, from the furnace to the flue, at some distance from the point at which the material to be burnt is introduced, or otherwise to ensure that all fumes evolved shall be thoroughly exposed to heat before being allowed to escape from the furnace; moreover, a steam blast, or other forced draught, has been employed with great advantage, and a temperature of from 1,500 to 2,000° F. has, by these means, been attained; under such circumstances a destructor can be worked without producing any nuisance.

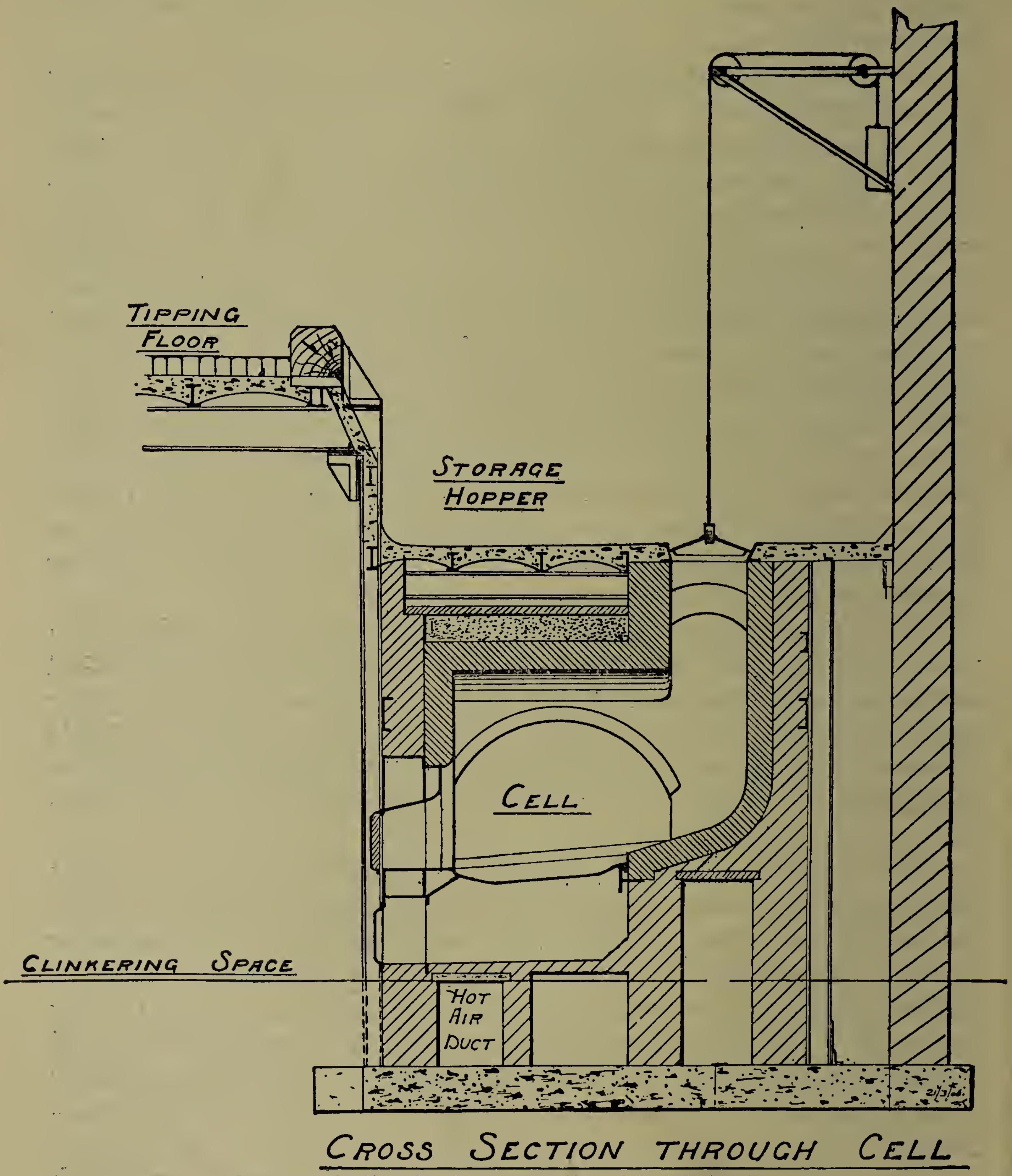

FIG. 38.—Section showing construction of dust destructor.

In high temperature furnaces, ten tons and upwards of refuse can be burnt in a day by each furnace cell; while in the low temperature destructors not much more than half this quantity can be dealt with. The wear and tear is greater in the case of high temperature destructors, but the increased efficiency more than compensates for this. The essential features, from the point of view of nuisance prevention, are that the temperature attained must be considerable, and the arrangment adopted such that all fumes evolved are exposed to great heat for a sufficiently long time to altogether prevent the escape of undecomposed vapour into the chimney-shaft.

II—ANIMAL REFUSE

The method employed for disposing of cow-dung, horse-dung, etc., is usually that of applying these materials to land as manure. Great nuisance is caused when large collections of dung have been allowed to accumulate, and are then disturbed in the process of removal. Dung receptacles should therefore be of limited capacity, and the emptying of their contents should be effected at frequent intervals ; again, it is of importance that they should be constructed of impervious material and protected from the rain, and on no account should they be sunk below the level of the ground.

The practice of using movable receptacles, on wheels, has much to recommend it. In stables it has become a common practice to use absorbent litter, sawdust, peat-moss, etc., with the object of soaking up urine and thus obviating the necessity of providing for drainage. Serious nuisance is apt to be caused if this plan is adopted, unless removal is effected frequently and with due precautions.

Bones, fat, and offal from slaughter-houses, other waste animal products, and especially fish and game offal, are apt to be a source of great annoyance. The scavenging should be carried out with such frequency as to ensure that decomposition is not far advanced, and effort should be made, by the use of covered receptacles, or, if necessary, of specially constructed tanks, etc., to prevent the escape of effluvia. Offensive animal material and night soil in places where the water carriage system is not in force, are sometimes conveyed through the streets at night time. This practice is open to objection, for it is desirable that any slopping or spilling which occurs should be at once detected and remedied, and hence removal in the hours of daylight is indicated ; it is, however, desirable that a time should be chosen when the streets are not frequented, and bye-laws, approved by the Local Government Board, usually specify, therefore, that the operations shall be carried out in the early hours of the morning.

III—LIQUID REFUSE

Household slops, the waste-water from kitchen sinks and from baths, drainage from cowsheds, stables and manufactories, street washings, and urine from public urinals, all contribute to render the liquid waste from communities eminently putrescible, and as a matter of fact it is found that the sewage from midden towns (in which human excreta do not obtain access to the sewers) does not differ materially in composition from the sewage of water-closet towns. The Rivers Pollution Commissioners (1868) found that "for agricultural purposes 10 tons of average water-closet sewage may in round numbers be taken to be equal to 12 tons of the average sewage of midden towns."

Under ordinary circumstances it is usual to discharge liquid refuse into the sewers. In the country where a midden or dry closet is in use a frequent arrangement when the nature of the soil is favourable is to apply the slop water to the land.

The piece of ground selected for the purpose usually requires to be underdrained; the waste waters are conveyed to it by a system of agricultural pipes with open joints, and in order to secure, as far as possible, distribution of the waste material over the whole extent of the land, it is usual to cause it to be discharged at intervals from a syphon flush tank.

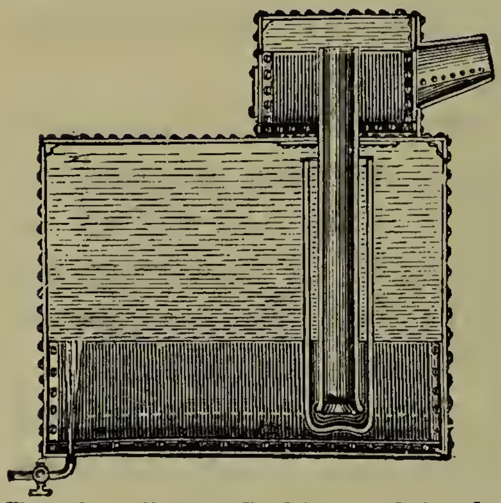
FIG. 39.—Rogers Field's Flush Tank.

For this purpose Rogers Field's "annular syphon tank" is often employed; the upper end of the descending arm of the annular syphon (see Fig. 39) has a lip projecting downwards and inwards, so that, when the waste-water reaches the level of the upper end of this descending arm, it is directed towards the centre of the tube by the lip, and, carrying air down with it, causes the syphon to be set in action; this result is satisfactorily attained even when only a small dribble of water is passing into the tank. The syphon, once put in action, empties the whole of the contents of the tank. In cases where such a device is not made use of, the waste-water, owing to the smallness of the amount of the discharge, is apt to penetrate only a short distance into the sub-irrigation pipes; by collecting the liquid, however, until a whole tank-full has accumulated, and then causing the entire amount to be discharged at a given moment into the drains, the waste-water penetrates further into the system of pipes, the proximal portions of which are thoroughly flushed out by the rush of liquid, and the whole area of the plot of land, which has been provided with sub-irrigation pipes, is utilised.

In the case of isolated habitations and small villages, where no system of sewerage obtains, liquid waste is with advantage collected in watertight *cesspools*, constructed of brickwork rendered in cement with a backing of well-puddled clay, properly covered and ventilated, and situated at a sufficient distance (at least 50 ft.) from any dwelling, and at least 80 feet from any source of water supply.

Liquid from cesspools has a most offensive odour; careful distribution over arable land or freshly dug soil seems to be the best means of disposal. Bleaching powder or lime dusted over the surface of the sewaged ground lessens the smell.

Water-tight cesspools with adequate attention can be made to answer fairly well when the water supply is small, but with a daily water supply of 15 gallons or more per head the cost of emptying is excessive and a sewerage system should be installed.

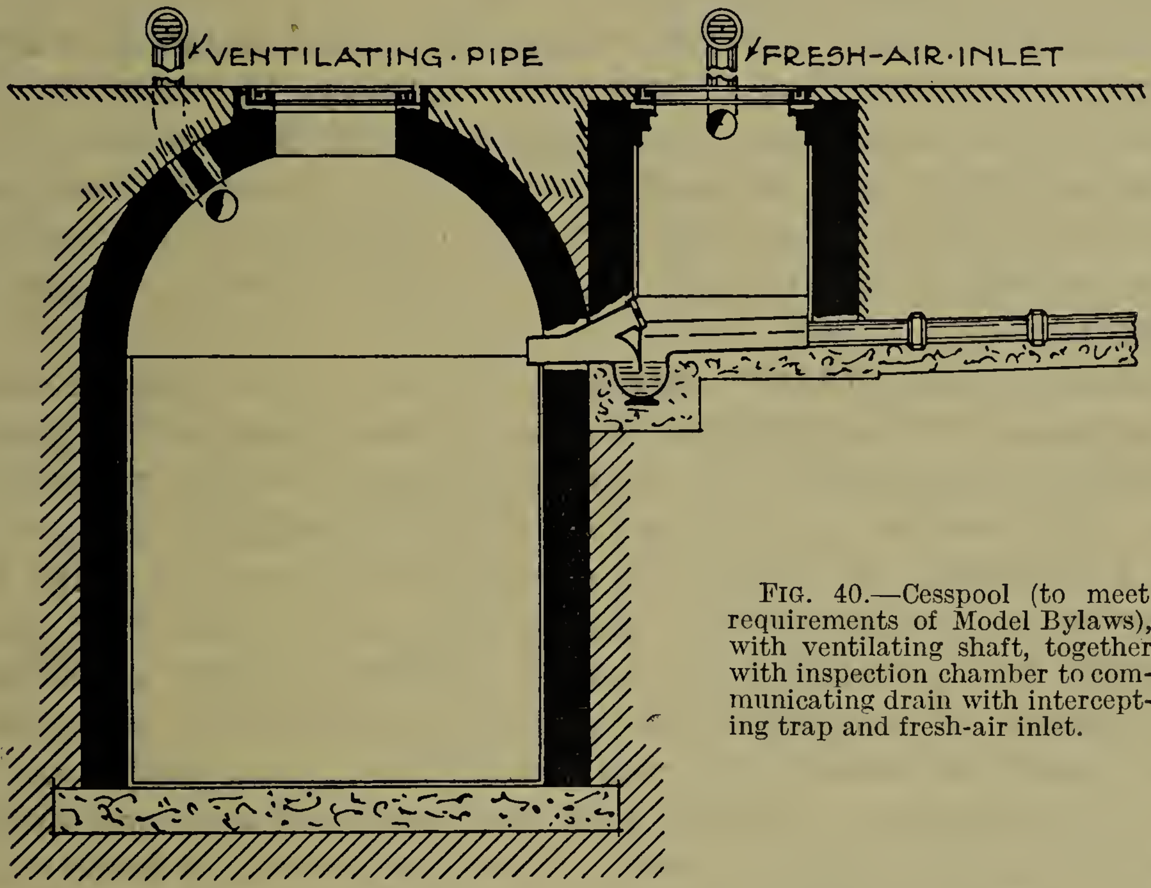

Fig. 40.—Cesspool (to meet requirements of Model Bylaws), with ventilating shaft, together with inspection chamber to communicating drain with intercepting trap and fresh-air inlet.

IV—EXCREMENTAL MATTER

Advantages and Disadvantages of Various Methods of Disposal—For the most part, no doubt, in former ages excreta were deposited in pits or dug into the ground, though, even in very early times, the method of conveyance of liquid refuse by sewers into the nearest watercourse was adopted in exceptional instances. The plan of covering excreta with earth, employed by some animals from time immemorial, was half a century or more ago made the basis of a method of practice generally associated with the name of a clergyman, the Rev. Henry Moule, who was the first to advocate the use of earth closets; this method is well adapted, under certain circumstances, for use in the case of isolated habitations.

When sewers came into common use for the purpose of carrying off surface water, and when the increasing employment of water for domestic purposes led to the discharge of this slop water into the sewers, it could not fail to be apparent that here was a means ready to hand for disposing of excreta.

Various crude forms of apparatus were from time to time recommended. In 1778, Joseph Bramah, a cabinet maker, patented a water-closet presenting considerable resemblance to the modern valve-closet, and it became a common practice, by means of appliances of this character, to wash excreta and other waste material into cesspools. In 1815 the law prohibiting the transmission of waste products from houses into sewers was repealed, and the convenience of the new system was so obvious, that from 1847 onwards it was made compulsory in many instances.

When this method of water-carriage had been commonly adopted, it became manifest that it was still necessary, in order to avoid nuisance, that much care and ingenuity should be exercised in connection with the construction of sewers. It was gradually recognised, moreover, that there was need for some method of dealing with the sewage carried to the outfall, before turning it into a watercourse or into the sea.

Side by side with the extension of the use of water-carriage, improvements were introduced in some of those centres of population in which the old system of depositing excreta in pits remained in force. The midden privy is not even yet altogether a thing of the past, but already, in the middle of the last century, its faults were beginning to be recognised. Constructed as it was "of porous materials, and permitting the soakage of filth into the surrounding soil, capable of containing the entire dejections from a house, or from a block of houses, for months and even years, undrained, uncovered and open to the rain and wind and the sun, and difficult of access for cleansing purposes," it was productive of most serious offence; but the difficulty of dispensing with it altogether led to efforts being made, while retaining the principle, to minimise the attendant danger and annoyance. To get rid of the liquid part, the sides and bottom were made impervious, and a drain inserted at the lowest part. A cover was provided to keep out the rain and the smell kept under by the addition of ashes.

Apart from the special difficulties of some localities, and the question of initial expense involved in putting in practice the method of water-carriage, there was this strong inducement in favour of the conservancy system—that the excreta in a dry form were of value as manure. Hence, in a number of cases the "midden" was still employed, and in instances in which public opinion was too advanced to permit of the continuance of the retention of large quantities of excreta under the old conditions, the less objectionable privy, or even "pail systems," were introduced; the tendency being, as the public taste improved, to insist upon smaller and smaller accumulations, and thus necessarily on more and more frequent removal.

In the privy walls were provided to facilitate cleansing and the floors raised to the level of the ground, also arrangements made so that the contents could be removed from the back. From this form it is but a step to the pail closet in which the excreta are passed directly into a movable receptacle placed under the opening of the seat.

Conservancy methods have, however, had their day so far as centres of population are concerned. The main cause of the failure of dry methods of excrement disposal appears to be that, where they are adopted, there still remains the problem of disposing of slop water, and, as already noted, the addition of water-closet refuse does not materially affect the composition of town sewage.

More than forty years ago attention was particularly directed, by G. V. Poore and others, to the capacity of the "living humus" of surface soil of dealing with excremental matter, and it was urged that in the light of modern knowledge, the water-carriage system involves waste of a "valuable manurial product." The average amount of excrement per unit of population is found to be about 2½ oz. of fæces and 40 oz. of urine, per diem, and it was then calculated, on theoretical principles, that if the nitrogen, phosphates, potash, etc., could be made available, the money value of the excreta of an individual *per annum* should be nearly seven shillings; to this amount the fæces would contribute about one shilling and the urine six shillings. Such calculations are of little importance in practice, as the excreta cannot, as a rule, be collected independently, and the attempt to extract the valuable constituents, after they have been mixed with other substances, is attended with great difficulty.

The Midden or Privy—This form of receptacle is still to be found in rural districts where the cost of water-carriage is found to be altogether prohibitive. The model bye-laws prescribe that a midden or privy shall be covered and ventilated, situated at least 6 ft. from any dwelling, and 50 ft. from any well; that the floor shall be above ground level, and shall incline away from the privy receptacle; the capacity of the latter is limited to 8 cubic ft., and this practically necessitates weekly removal; the receptacle, moreover, is to be of impermeable material, so as to prevent soakage, and it should have a hinged seat to admit of the application of ashes.

Earth Closets—Fæcal matter mixed with suitable dry earth loses its offensive smell and becomes unrecognisable in a short time. Any ordinary garden soil can be used for this purpose but sand, gravel, and chalk are unsuitable. Liquid such as household slops must not be added; the whole of the urine cannot be dealt with by this form of closet. In the closet should be placed a box containing an adequate supply of fresh dry garden mould and a shovel. Sifted ashes can be used, but are much inferior to garden soil. No disinfectant should be added. The same earth should be used over and over again; it can be used about eight times, but must be kept dry. Enough mould should be added each time the closet is used to keep the contents of the pail moist but not wet. The pail when full should be tipped in a sheltered corner of the garden and the heap covered with a piece of corrugated iron to keep the rain off. It should contain enough earth for five or six pailfuls and is with advantage stirred once a week. When the efficiency of the earth is at its height "small red worms" appear; paper is disintegrated in three to four days. Eventually the contents of the pail should be buried in a shallow trench 3 inches or so deep. In other forms of earth-closet, by depressing a handle or by means of a rocking seat the requisite quantity of dry earth is shot into the pail from a receptacle above the seat but in practice these devices are not so satisfactory as the addition of earth by hand.

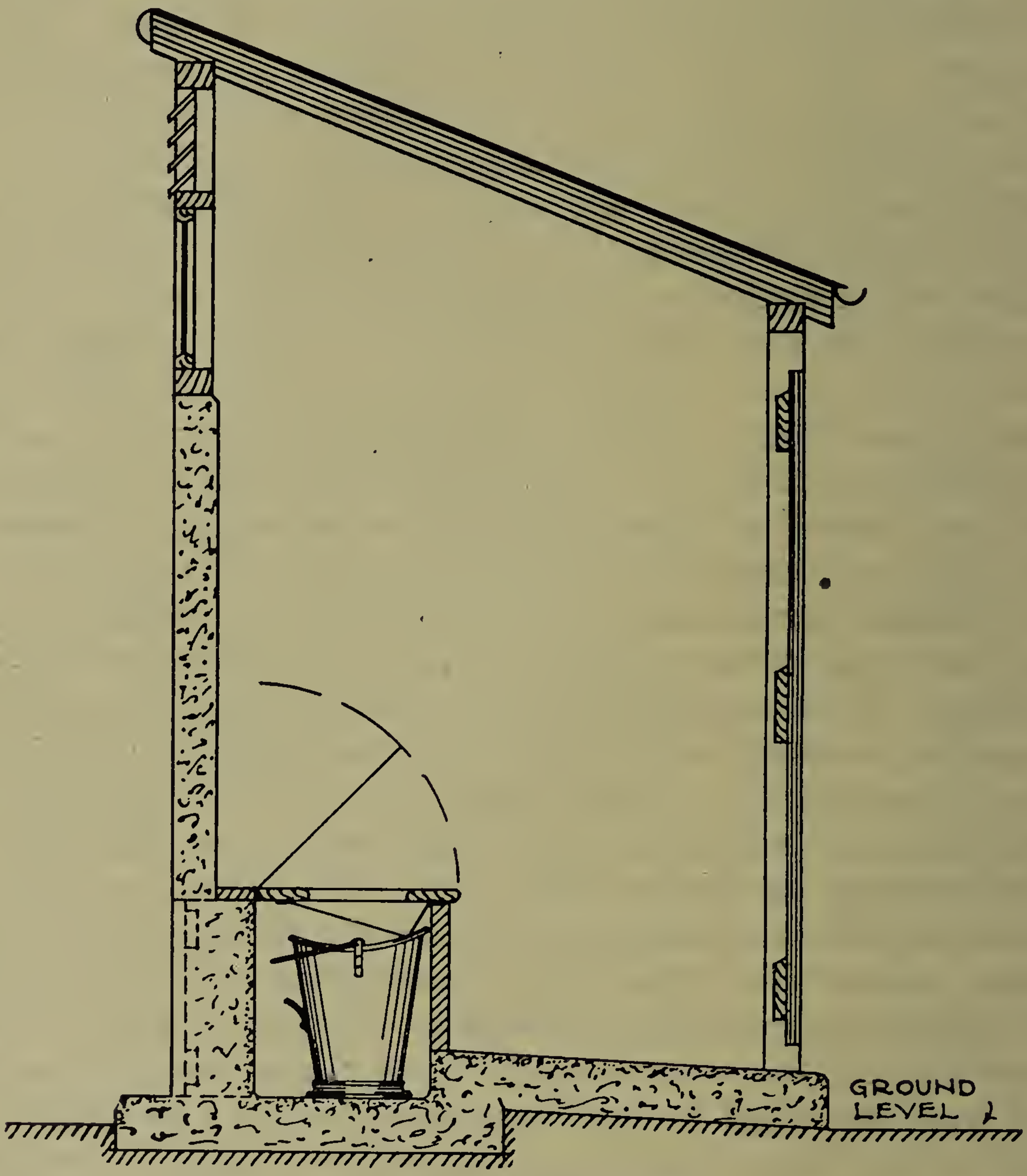

FIG. 41.—Privy with movable receptacle in accordance with Model Bylaws.

The earth-closet should be placed as far as possible from the dwelling, having regard at the same time to the convenience of the occupants.

Earth closets require careful supervision to ensure the regular emptying of the pails; they entail extra labour in the preparation of soil, removal of the pail contents, the provision of dry earth, etc. They are especially useful in those rural district areas immediately outside a special drainage district where the lie of the land and other reasons would render its inclusion as a contributory place inadvisable.

Earth closets are preferable to cesspools in districts where the normal level of the subsoil water lies within a few feet of the surface; in such places advantage is taken of this and cesspools are seldom made water-tight.

Pail closets are in use in many rural areas and also in a few large towns, especially in the north of England. At Rochdale a wooden pail was used. In Halifax the Goux system was introduced, the pail being lined with an absorbent layer of ashes, street sweepings, factory waste, or a mixture of tan, sawdust, and soot, pressed into shape by means of a mould. Ash-closets are sometimes provided, in which, by a mechanical arrangement, sifted fine ash is deposited automatically on the pail-contents, while the cinders are separated for further use as fuel.

In all pail closets (including earth closets) the pail must stand in its proper position under the seat; for this purpose a recess should be made in the floor for the bottom of the pail. The floor should be made of impervious material, preferably concrete brought to a smooth surface with a mixture of equal parts of Portland cement and sand. The pail must be frequently emptied—daily in hot weather; it should be rapped quite empty, scraped inside if necessary and well dusted internally with fine soil before replacing. A movable cover keeps the flies out of the pail. A minor difficulty arises in connection with the urine—unless urine guards, pieces of sheet metal, are placed inside the front of the seathole the urine often passes too much forward and collects under the seat.

The chief hygienic objections to the use of pail closets are those consequent on the retention of fæces in the neighbourhood of dwellings. In the country especially, the pails are not changed often enough and the contents spill over: again, during their removal a certain amount of spilling often takes place, and the place under the seat and the surroundings are fouled. When the fæces contain any pathogenic organisms such as typhoid bacilli a certain amount of danger arises affecting both the occupants of the houses and the night-soil men, who remove the pails. The danger is reduced as far as possible by arranging a more frequent collection of pails from houses where patients with typhoid fever are being nursed at home, and the pails are especially marked so that the nightsoil men may be exceptionally careful in handling them.

In towns the removal of pails is usually carried out at night-time, in specially constructed vans, and the material collected is generally concentrated into smaller bulk by application of heat, and utilised as manure. In Paris, cesspool sediment has been dried on a large scale, and so converted into what is known as *poudrette.* In the early days of the employment of systems such as the above, it was found that, while none of them paid the cost of collection, they were in some instances more economical than water-carriage removal; but of late years increasing difficulty has been experienced in disposing of the product manufactured, and this fact, together with the necessity for the independent removal of liquid waste, and the objection to the pail system on health grounds, has led to a gradual abandonment of these conservancy methods.

Application to Land—In cases where there is abundant garden ground about houses, the application of excreta to the surface soil has been practised with advantage; when conducted with scrupulous care, the system has not been attended with nuisance, and the added material has been found to be a valuable fertilising agent. It has been contended that, relying upon the capacity of the "living humus" to render innocuous material deposited upon it, the operations may be conducted in the near neighbourhood of properly constructed surface wells, and that the risk of pollution is then even less than with a water-carriage system and with public supplies of water. Such a method is, of course, quite out of the question in the case of urban communities, especially as all conservancy methods are expensive as regards maintenance and working cost if properly carried out.

The decline of *typhoid fever* in this country coincidently with the carrying out of extensive works of sewerage (the mortality from the disease was ·37 per 1,000 in 1871–5, and ·17 per 1,000 in 1891–5), and the fall in the death-rate of Glasgow subsequent to the provision of an improved water supply (·51 per 1,000 in 1865–79, and ·19 per 1,000 in 1887–97), together with other facts seem to conclusively dispose of the doctrine, held especially by Poore, that the introduction of sewers, water-closets, and public water supplies has led to increased risk of disseminating typhoid fever.

In fact conservancy methods in towns are now held responsible for some measure of typhoid fever. In Nottingham, for instance, the average yearly number of cases of typhoid fever were :—

1 in every 45 houses provided with midden privies.
1 ,, 217 ,, ,, ,, pail closets.
1 ,, 376 ,, ,, ,, waste water closets.
1 ,, 861 ,, ,, ,, water closets.

The conversion of pail closets has in some towns, *e.g.*, Leicester, been associated with a striking decrease in the diarrhœal death-rate. The following comparison of the proportional diarrhœal mortality of two fairly similar towns, Leicester which has substituted water closets for pails and Nottingham where pail closets served more than half the town up to 1909 has been made.

	1889–93.	1894–8.	1899–1903.	1904–8.	1909.
Leicester . .	100	115	89	78	48
Nottingham . .	100	139	145	119	96

It might be objected that country villages provided with privy middens and pail closets escape a heavy diarrhœal mortality, but here careful management of the conservancy methods of excremental disposal prevails, a higher standard of cleanliness among rural cottagers is found and there is a smaller density of infant population resulting partly from the lower birth-rates in country districts.

A great difficulty in connection with the introduction of water-carriage removal was, of course, the initial outlay involved. This obstacle was to a large extent overcome by the institution of the loan system. Again, the manurial value of excreta, collected under the old conservancy methods, was far greater in the early days, when farming operations were conducted in this country on a much more extensive scale than they are at the present time. Comparison of the acreage of land under cultivation at the time of the accession of Queen Victoria, with that under cultivation at the present day, will show that the importation of food supplies from abroad has, from an economic standpoint, wrought great changes in the conditions of the problem of excrement disposal.

In some places ordinary water-carriage systems are out of the question, by reason of difficulty in obtaining a proper fall, or owing to severity of climate leading to freezing of water, or from insufficient supply of water.

Shone's Ejector System is used in towns lying on flat land where it would not be possible to provide an adequate gradient for ordinary continuous sewers. The sewage passes to "ejectors," cylindrical reservoirs in chambers situated under the streets at different parts of the town; when these are full compressed air is admitted and the sewage forced into a sewer at a higher level. Liernur's system is used in towns similarly situated but where there is the additional difficulty of an inadequate water supply. The sewers are airtight; the sewage is drawn into a central station for treatment by means of a vacuum produced by an air pump.

Water-closets and the Water-carriage System—In modern houses the arrangements for the disposal of sewage include—Water-closet with a trap, soil pipe, house drain, intercepting trap, sewer.

Water-closets—The water-closet apartment should be built against an outside wall, and if possible, it should be provided with a disconnecting lobby, so that cross ventilation can be obtained between the water-closet and the interior of the house. On no account should it be approached directly from a living-room, work-room, or place in which food is stored. The apartment should be well lighted, and should be ventilated by means of a window opening on to a sufficient open space; in addition to this, means of permanent ventilation by an air brick or air shaft should be provided. The floor of an outdoor closet may with advantage be made of cement-concrete, with a fall towards the door. The trap should be embedded in cement so as to form a firm immovable pedestal; there should be no wooden covering in front of it, as in the absence of such covering cleansing is facilitated. The seat of the closet should, moreover, be hinged.

Many forms of water-closets are in use. They consist essentially of a pan or basin flushed by means of water and connected by a trap to the soil pipe.

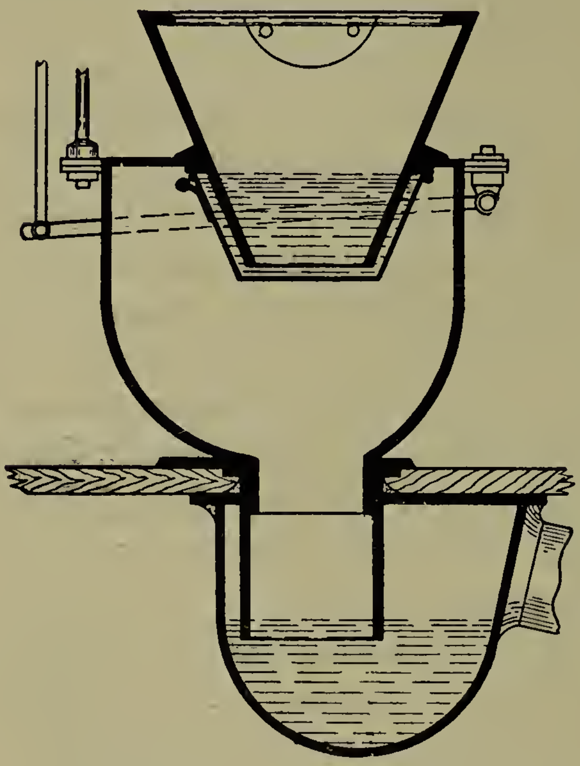
FIG. 42.—Pan closet with D trap.

In Figures 42 and 43 two forms of water-closet, at one time in common use, but now, fortunately, becoming extinct, are shown: the *pan closet*, in which the contents of the water-closet basin were discharged into a "*container*," usually placed in communication with a "D trap," was particularly objectionable. The container and trap invariably became coated with deposit, and the leaden D trap was in some cases actually perforated. When the closet was used, and the pan discharged into the container, the effluvia evolved in the decomposition of the filth on the sides of the container escaped into the house. It was, moreover, a common practice in connection with these closets to take the discharge-pipe from the leaden safe placed under the water-closet direct into the D trap, and in this way further opportunity was afforded for the escape of drain air into the house.

The *long hopper* closet is also open to objection, as excreta falling upon the sides of the basin render it foul, and ordinary flushing appliances are, as a rule, found to be quite incapable of cleansing it. Such closets, when furnished, as at one time they not infrequently were, with a "spiral flush," were sources of serious nuisance. The model bye-law of the Local Government Board provides "that the water-closet basin shall be composed of non-absorbent material," and be "of such shape, of such capacity, and of such mode of construction as to receive and contain a sufficient quantity of water to allow all filth, which may from time to time be deposited (in it), to fall free of the sides thereof and directly into the water."

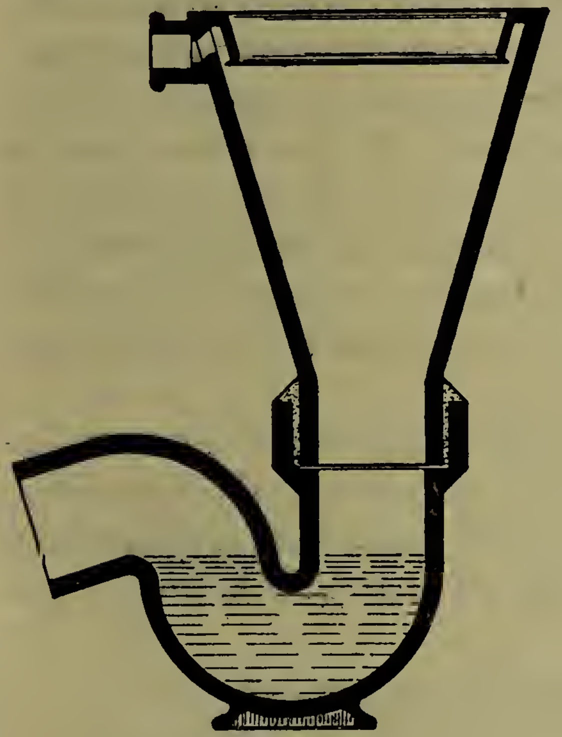
FIG. 43.—Long hopper closet.

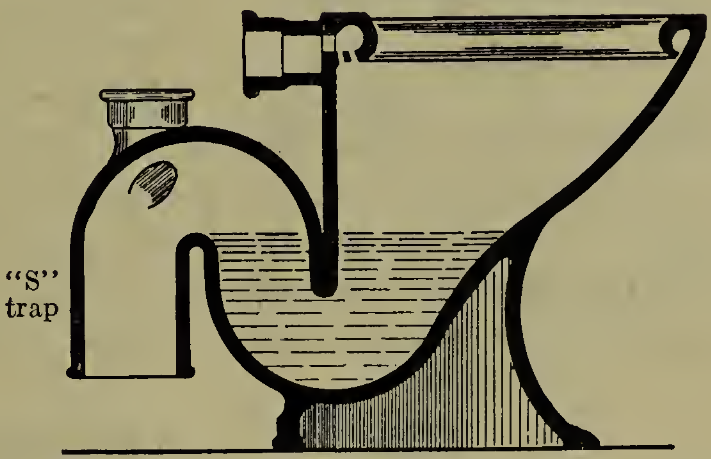

FIG. 44.
Short hopper or wash-down closet (satisfactory).

In the *short hopper* or *wash-down* closet these conditions are generally complied with, though there is considerable difference between the various types of apparatus in common use, in this respect; the back of the basin should be almost vertical, and the area of the contained water should be sufficient to permit of all filth being received directly in it. The junction of the basin and trap, if the two are not made in one piece, should be carefully effected, so that the internal surface is here perfectly smooth, and no projecting edge, such as would favour the collection of filth, is left.

A short hopper of stout glazed stoneware is the best cheap form of water-closet.

In the *wash-out* closet the area of the water held in the basin is considerable, but the upper part of the syphon trap above the water-level is apt to become foul; hence this form of closet is generally productive of more or less nuisance and is never fixed in London nowadays. In the figure, an "after-flush chamber" is shown; this con-

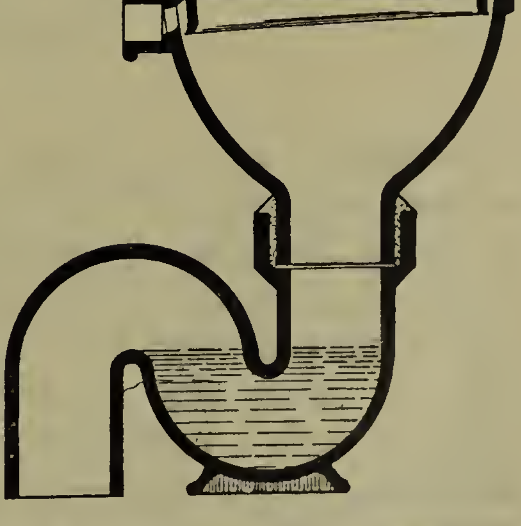
FIG. 45.—Short hopper with central outlet (unsatisfactory).

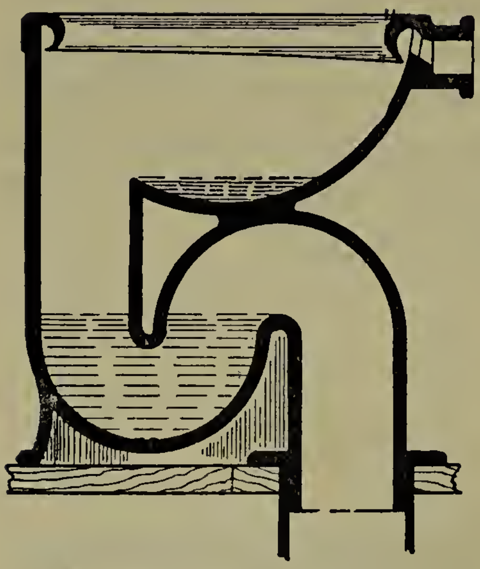

Fig. 46.—Wash-out closet.

trivance is designed with the object of receiving some of the flushing water, and gradually allowing it to drain into the basin, so as to ensure that the trap shall be fully recharged in case too much water has been carried out of it by the rush of water which first occurs.

Syphonic closets present the general characteristics of the wash-down type, but the contents of the basin are, in them, drawn out by syphon action in addition to being washed out by flushing. Some of the common types use 3 gallons of water at each flushing and do not effect an economy in the use of water.

The *valve-closet* has the lower part of the basin closed by a water-tight valve, which can be depressed into a metal box, thus enabling the contents of the basin to be discharged into the syphon trap beneath; an overflow-pipe, which should be trapped, is also made to discharge into the box; as the trap of this overflow-pipe is apt to become unsealed, by evaporation or syphonage, it is the practice, in some instances, to ventilate it to the outer air by means of a "puff pipe," and to adopt an arrangement by which the overflow-pipe is flushed each time the closet is used. It is advisable, moreover, to cause the overflow-pipe to enter the box underlying the valve in such a position that when the valve is depressed the opening of the overflow-pipe is covered, and choking by paper, etc., thus obviated. The valve-closet possesses the advantage of having a large

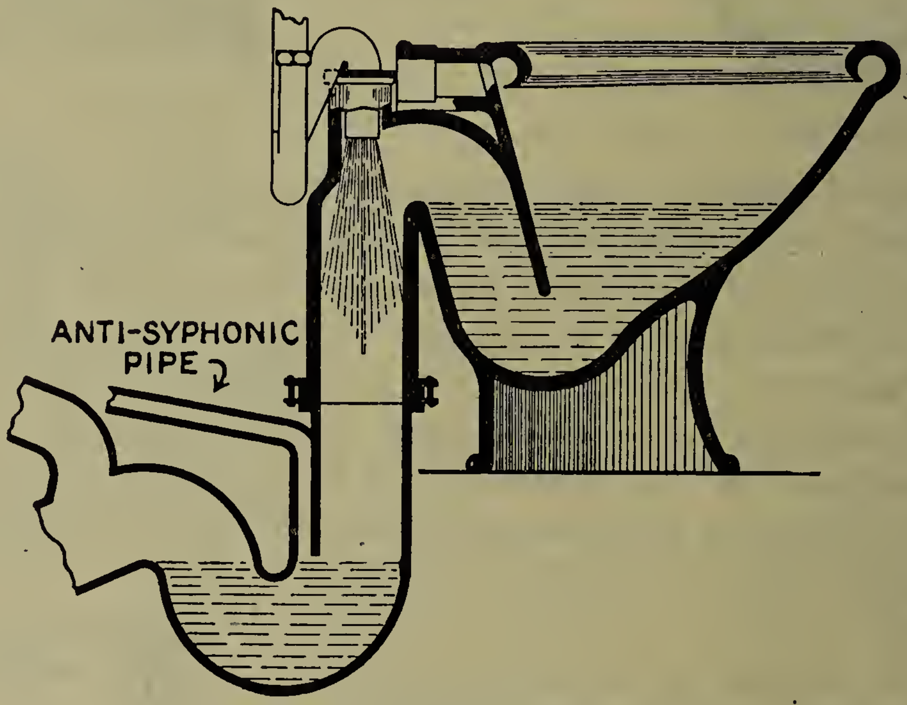

Fig. 47.—Syphonic water closet.

area of water contained in the receptacle, but the valve is apt to get out of order, and a larger amount of water is necessary for flushing than in the case of other forms of closet, inasmuch as an "after-flush" has to be provided for, in order that the level of the water may rise in the basin after the valve is closed. With a view to supplying this after-flush, a "bellows regulator," consisting of a piston (moving in a cylinder) connected with the handle which serves to open the valve of the closet and that of the supply pipe, is usually employed. When the handle of the closet is lifted the piston of the regulator is raised, but when the handle is released the water continues to be supplied as the piston of the "bellows regulator" gradually falls; the cylinder of the regulator has an air-escape pipe, fitted with a tap, which regulates the escape of air from the cylinder and thus governs the rate of descent of the piston. While the piston is descending, the supply valve remains open, and water continues to enter the closet basin.

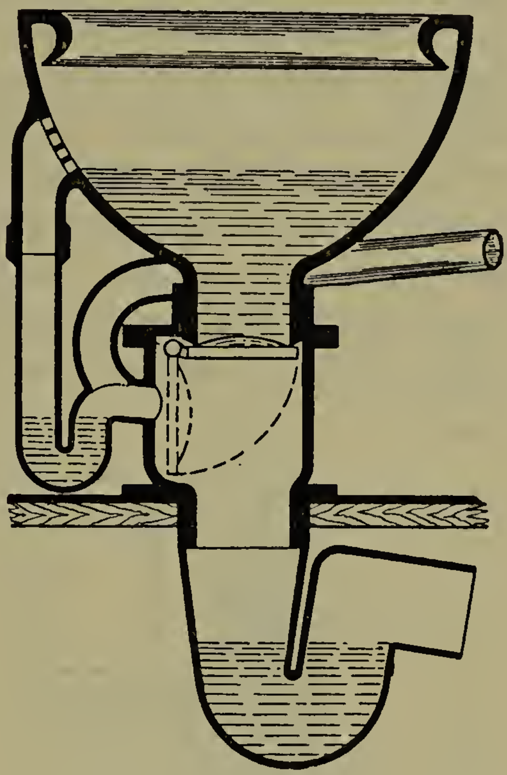

FIG. 48.—Valve closet.

In all cases water-closet basins should be provided with a flushing rim which directs the water over the whole surface of the basin. The down pipe should not be less than $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in diameter, and the cistern should be placed at least 4 ft., and preferably 6 ft., above the closet basin, in order to obtain a sufficiently forcible discharge.

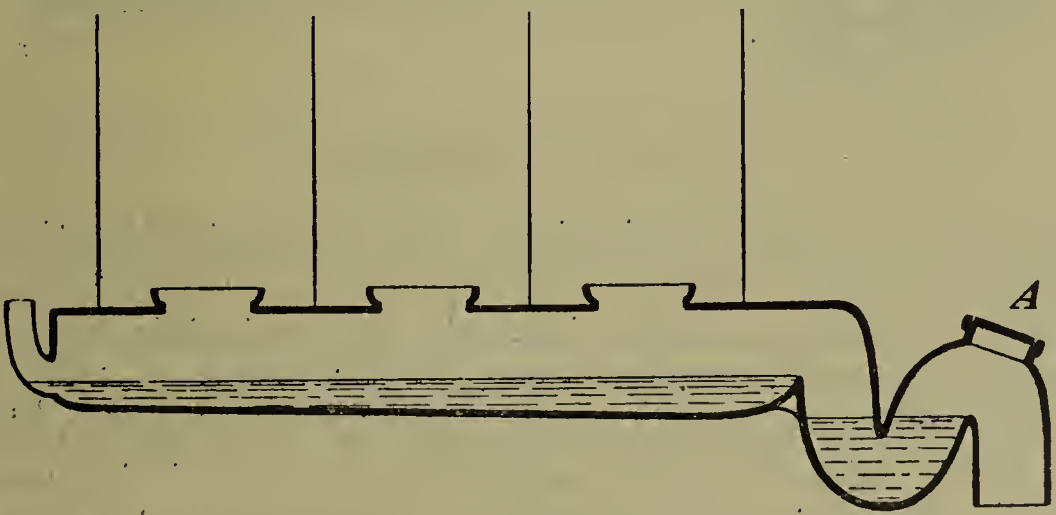

FIG. 49.—Older type of trough closet. A, cleansing cap.

Trough closets are still used in schools and institutions, and in other instances when a number of closets side by side are required.

It is said that they are less costly, and are adapted for the use of persons who, from recklessness or sheer mischief, interfere with the working of the flushing or other apparatus of ordinary water-closets. The trough closet can be automatically flushed, and, if the operation is effected at sufficiently frequent intervals, it is contended that nuisance from the accumulation of excreta in the closet will not be experienced. The sides of the trough are liable, however, to become foul from splashing, and if they are not periodically cleansed nuisance must arise from this cause. Improved forms of trough closets, styled "latrines," have been constructed, in which a number of basins, shaped like ordinary water-closet basins, communicate with a trapped discharge pipe common to all of them. These appliances are less open to objection in some respects than the ordinary "trough closet"; but, on the other hand, they do not, as a rule, admit of being properly cleansed. The principle of retaining excremental matter, even if it be for only short periods, before causing it to be discharged into the drain, is undoubtedly objectionable, and even with the most careful management it is practically impossible to maintain such a standard of cleanliness with the trough closet, or latrine, as can be secured where separate water-closet basins are employed. In many places in which trough closets have been tried, they have been found to be a source of considerable nuisance,

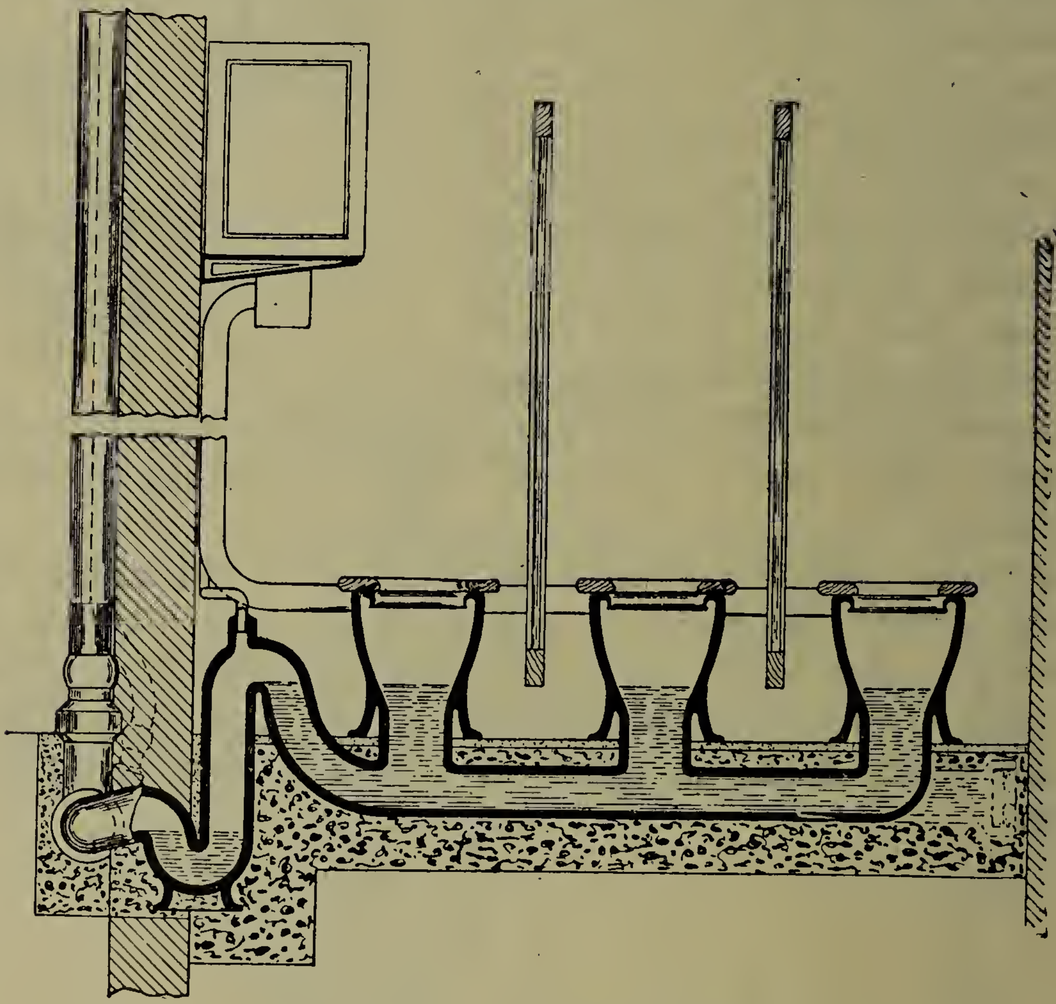

Fig. 50.—Newer type of trough closet.

and in numerous instances it has been found desirable to replace them by ordinary water-closets.

Soil pipes conduct the excreta from the water-closet to the house drain. They are made of lead, or cast or galvanised iron. Drawn lead is generally used; in seamed lead piping leakage is apt to occur at the seam; its use is prohibited by the London County Council bye-laws. Any joint should be a wiped joint. Iron pipes are inferior to lead; if employed they should be of a uniform thickness of not less than $\frac{3}{16}$ to $\frac{1}{4}$ of an inch; they should be properly tested, and jointed with yarn and molten lead, and the connection with the closet requires to be carefully made in order to secure proper jointing. Even where iron pipes are used as soil-pipes it is advisable to employ lead for the ventilating pipes as iron, when not washed by sewage, speedily rusts and deteriorates.[1]

The size of the soil pipe should be such as to allow of its adequate flushing; a diameter of $3\frac{1}{2}$ inches is allowed for dwellings by the L.C.C. bye-laws; if more than 4 inches the pipe is too wide for strength and too heavy.

All soil pipes should be placed on the outside of the house. For the purposes of ventilation they should be carried up full bore beyond the point of entrance from the highest water-closet above the eaves, to open clear from all windows and chimneys.

House drains are usually constructed of circular glazed stoneware socketed pipes in lengths of about 2 feet. These pipes are more durable and less porous than earthenware pipes, from which they are distinguishable by their pale buff colour, their metallic ring when struck with a hammer, and the comparatively small extent to which their weight increases when, after drying, they are submerged for twenty-four hours in water.

They should be carefully laid and jointed with Portland cement in such a way that there is no projection at the site of the joint into the interior of the drain.

The absence of such projection is usually ascertained by the use of a "badger," a wooden disc or ball, which can be passed along the interior of the drain. Two wooden discs, edged with india-rubber and connected by a flexible tube, are sometimes employed for the purpose, as this form of badger can be made to closely fit the pipes, and is capable of being drawn through bends in the drain. "Composition rings," cast on the spigot and socket of each pipe, are sometimes used for jointing purposes; when they are employed a fillet of cement is often added in addition to make the joint perfectly secure. It was a common practice in days gone by to make clay joints to house drains, but in places in which the laying of drains is adequately supervised, proper joints are, of course, insisted upon.

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[1] The drainage bye-laws of the L.C.C. require that soil pipes within buildings shall be coated on the outside and inside with Angus Smith's solution or some equally suitable material against corrosion; ventilating pipes within a building must be similarly coated on the inside.

Cast-iron pipes are often employed for drainage work; they can be manufactured in long lengths, hence fewer joints are necessary, and these can be made in a more reliable way when such pipes are used. Moreover, cast-iron pipes are readily adapted to different varieties of form. They are especially useful when drains have to be carried under houses and under roads used for heavy traffic.

Cast-iron pipes are generally coated inside and out with Angus Smith's preservative (a mixture of coal tar, pitch, linseed oil and resin), or with oxide, by the Bower-Barff process (raising to white heat in presence of superheated steam). Those parts of iron pipes which are exposed to ordinary sewage show little tendency to rust, a fact attributed to the contained grease, etc.

The diameter of the drain varies according to the amount of sewage to be carried, 4 inches being the ordinary size of a house drain for a private house, 5 or 6 inches for any larger building.

There is an advantage in not using drain-pipes of larger size than this, as the smaller the diameter the greater is the likelihood of the drain being adequately flushed and kept free from deposit. The amount of water necessary to make a 4-inch pipe run full, causes a 6-inch pipe to run less than half full.

It is most important that drain pipes should be laid to a proper fall and on a bed of concrete. In some instances concrete is not insisted upon when the drains are entirely outside the house and the subsoil is "sound." The pipes should be placed with the sockets pointing to the head of the drain, and the gradient should be at least 1 in 40. Maguire's rule is to the effect that a 4-inch drain must have a fall of 1 in 40, a 6-inch drain a fall of 1 in 60, and so on, the diameter of the drain in inches being in each case multiplied by 10.

Drains intended to carry sewage should always be laid on 6 inches of concrete, and the concrete should project on each side to an extent at least equal to the external diameter of the drain. Leaky pipes and joints are often caused by careless filling in of the trench, especially near points where pipes, are supported by a rigid foundation, for example, close to a manhole. Unless the re-filling of the trench has been thorough and the foundations beneath the pipe where it leaves a manhole thoroughly consolidated, leaky joints or cracks can readily occur where the pipe is rigidly held in the manhole wall and not so firmly supported outside.

If the drain pass beneath a dwelling-house, the entire pipe should be encased in concrete 6 inches thick all round. When drains are laid beneath houses, relieving arches in cement should be formed, where the pipes pass under walls, so as to prevent possible damage to the drain from settlement. Iron pipes are best adapted for use in cases where drains pass under buildings, and they may be laid on concrete, or placed in brick channels with concrete floors, so that they are accessible to inspection throughout their entire course beneath the building. Drains should be laid in straight lines; if it is necessary to change the direction of the drain, this is best effected by employing a curved pipe as the means of communication between one run of drain pipe and the next.

An *inspection opening or chamber* should be provided at every change of direction, so that, in the event of the drainage becoming blocked, the places where blockage usually occurs can be inspected without taking up the ground.

At the site of the junction of the house drain with the sewer an inspection chamber should be constructed, whenever this is practicable. In the inspection chamber the disconnecting trap, which is usually provided at the point where the house drain joins the sewer, should be so placed that it can be exposed for purposes of examination. The chamber is generally constructed on a concrete foundation of brickwork lined with cement. The main drain of the house should run across the chamber, in an open channel formed of half-channel pipes. Branch drains should be made to communicate, where this is practicable, with this open chamber by suitable curved pipes; and the outlets from the drains being thus exposed any obstruction can be readily removed by operating from within the chamber.

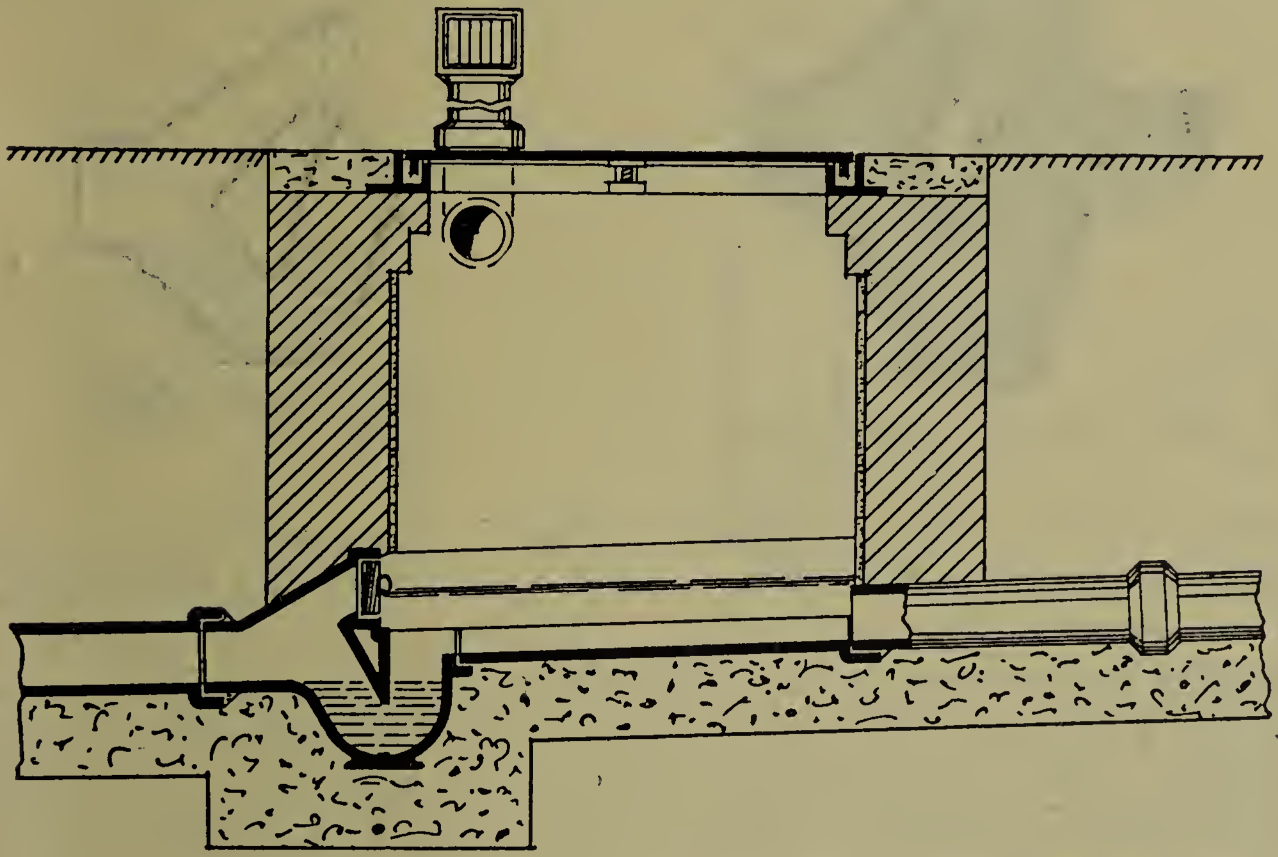
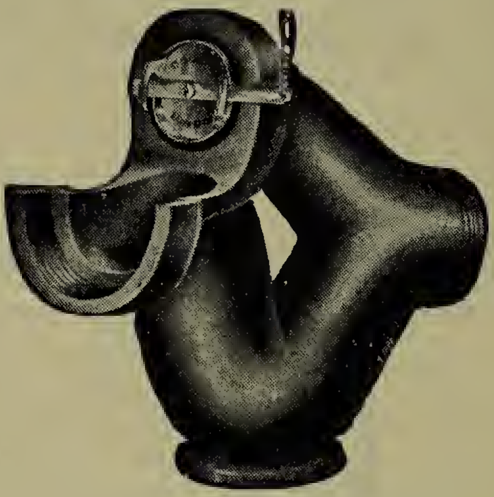


FIG. 51—Inspection chamber with intercepting trap, open channel and fresh-air inlet.

The branch drains should be three-quarters channel to prevent splashing. The sewer interceptor should be provided with a raking arm for cleansing purposes. It is often provided with a plug, operated upon by means of a chain which on being raised allows means of escape, for any sewage which may have collected in the chamber, through the raking arm to the sewer. This arrangement is convenient, as it obviates the necessity of baling out sewage from the chamber, in the event of any obstruction occurring in the disconnecting trap, inasmuch as by merely pulling the chain any liquid which may have accumulated in the inspection chamber can be caused to flow away into the sewer.

It is not unusual to find that the disconnecting trap has been so fixed that its outlet is at a somewhat higher level than its inlet. If this be the case, backing up of sewage occurs, for the contained material necessarily stands in the drain at the level of the outlet of the trap. Again, collections of sewage are caused if the fall of the drain be not carefully regulated. When it is necessary to connect pipes of unequal diameter—for example, a 4-inch and a 6-inch drain —a " taper pipe " should be used. This pipe should be adjusted so that its lower surface, along which the sewage flows, and the corresponding surfaces of the pipes which it connects, present uniformity of slope, while its crown and sides must be so shaped as to effect the necessary tapering ; if this is not done the flow of sewage in the drain will be interfered with.



[FIG. 52.—Manhole channel trap with raking arm.

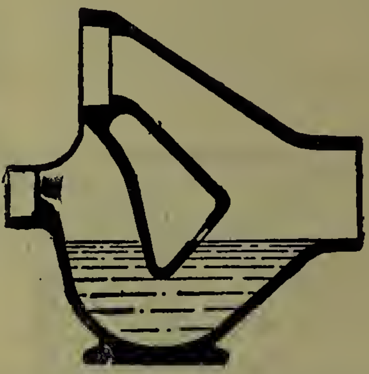


FIG. 53.—Section of manhole channel trap with raking arm.

Investigations and experiments carried out by the Departmental Committee of the Local Government Board in 1908 showed that the disconnecting trap can often be dispensed with without any danger to health ; also that it is a permanent obstruction in the drain and is the main cause of stoppage of house drains, frequently getting blocked, especially where the gradients are flat. Foul water is retained in the drain at the trap. In the case of the drainage of groups of new buildings it is a positive advantage to omit the trap and to allow every soil-pipe to ventilate the sewers. The Ministry of Health have allowed the omission of the trap recently in certain housing schemes ; in several others one disconnecting trap has been inserted for the whole of a small housing area and in a number of larger schemes a single trap has been supplied for groups of from four to twenty houses. The trap should however be retained when the house drain is connected to a cesspool or when the general sewerage system of the town is badly ventilated as is likely to occur when a housing area is situated at a high level and the town itself lies low; also in the case of old buildings where the drains and soil-pipes or ventilators may be defective.[1] In omitting the trap care must be taken to see that the joints of every soil-pipe are sound. The omission of this trap allows a rat to penetrate as far as the trap in a water closet. The London County Council by-laws require the installation of disconnecting traps.

TRAPS

The object of a trap is to prevent the foul air from drains escaping into a dwelling or into the open air in the neighbourhood of dwellings. Most traps are used in connection with a flush of water. Such traps should be so constructed as to be completely washed out by every flush of water passing through them, *i.e.*, be self-cleansing.

The *syphon trap* acts satisfactorily. It consists of a pipe looped on itself, the farther limb being either another complete loop (an S trap) or only slightly bent (a P trap). Water is contained in the lowest part of the bend; the water seal which prevents the passage of air or gas from one side of the trap to the other is the vertical distance between the level of the water and the lowest point of the bend of the upper surface of the tap.

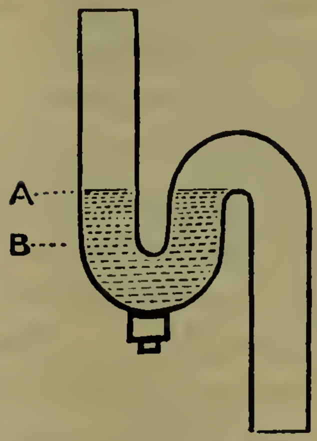


FIG. 54.—Syphon "S" trap, with screw-plug for cleansing.
A, B, water seal.

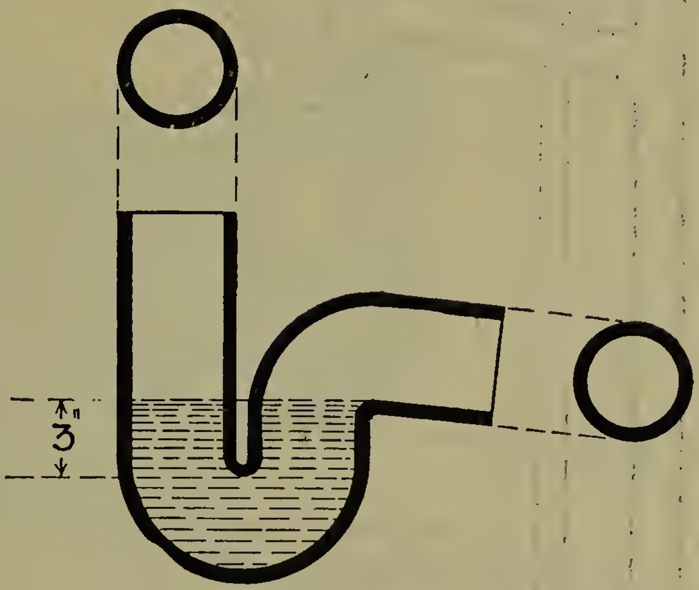


FIG. 55.—"P" trap, showing a 3″ water seal.

This water seal should be at least 1½ inches deep. The air of the drain to some extent obtains access to the interior of the house, even when the seal remains unbroken, for drain air becomes absorbed by the trapping water, and may be given off from its upper surface on the house side. Fergus, of Glasgow, found that substances with characteristic odours, introduced on the drain side of the trap, become perceptible on the house side after the lapse of an interval of time; thus ammonia was found to be taken up by the water in the syphon, and to be transmitted through it to the air on the house side of the trap, in sufficient quantity to become perceptible after the lapse of about fifteen minutes. Moreover, if the contents of the drain be foul, putrefaction may occur in the water of the trap, with bursting of bubbles and discharge of particulate matter into the air on the house side of the trap.

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[1] See paper by E. R. Matthews, "Journal of Municipal and County Engineers," July, 1921.

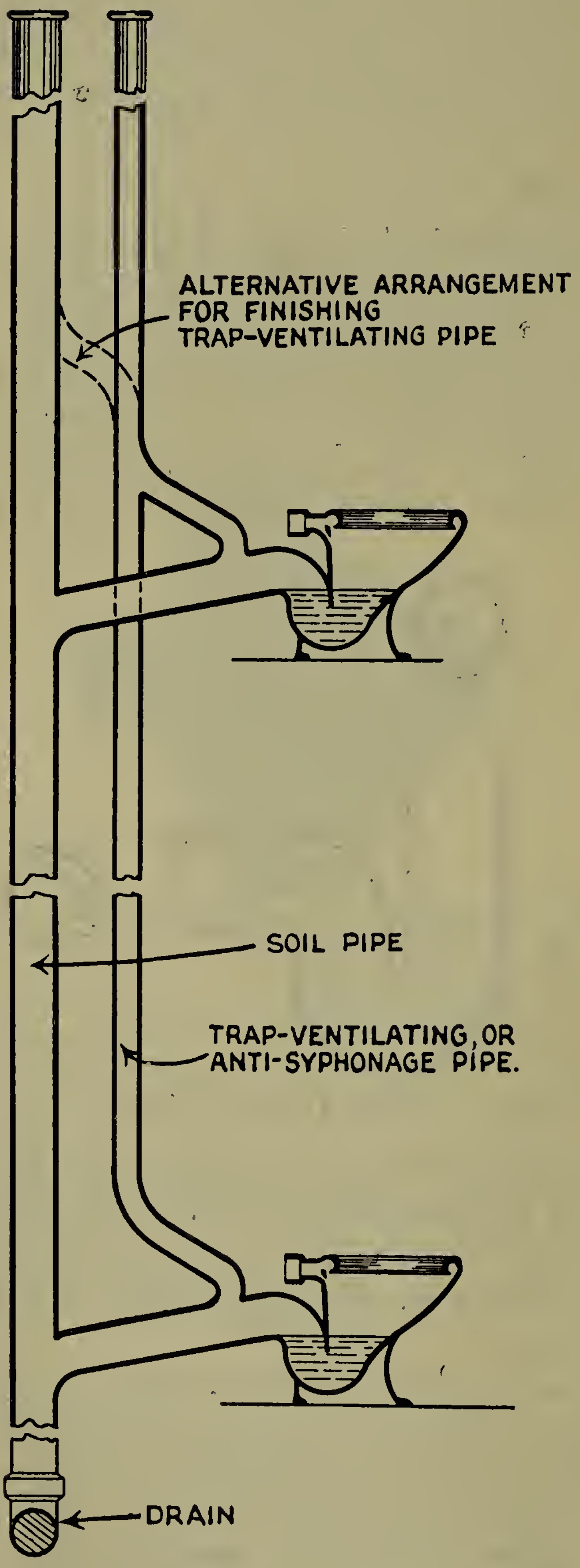
ALTERNATIVE ARRANGEMENT FOR FINISHING TRAP-VENTILATING PIPE
SOIL PIPE
TRAP-VENTILATING, OR ANTI-SYPHONAGE PIPE.
DRAIN

Fig. 56.—Sectional elevation showing arrangement of water-closets on two floors with soil and trap ventilating pipes.

The water seal may thus become broken from excess of pressure in the drain, if the latter be unventilated. Again, the momentum of discharge may carry the water altogether out of the syphon, or drive out so much water as to cause the trap to become unsealed, particularly if the depth of the seal be insufficient; this is obviated by causing the water-holding part of the trap to be somewhat contracted, and by making the ascending arm large and square in section. The seal of a trap may become broken by the evaporation of the water contained in it.

"Syphonage" is at times responsible for sucking out the contents of the trap and is specially apt to occur when a soil-pipe is common to several water-closets, one above the other, as, for example, in a block of buildings; the suction caused by water passing down the common soil-pipe past the opening of the drain into the common soil-pipe is apt to drag out the contents of the drain and trap. If an "anti-syphonage" pipe (puff pipe) be used to ventilate the trap on the soil-pipe side it is easier for air to be drawn down the anti-syphonage pipe when suction is exerted than for the heavier water to be drawn out of the trap.

A trap, to be efficient, should be self-cleansing, and for this purpose it is necessary that it should be free from all angles and corners which would tend to retain filth.

Traps for sinks, wash-hand basins, and baths are made by bending the waste pipes (usually leaden) on themselves. A hole, closed by a screw cap, should be provided at the lowest part of the trap to facilitate cleansing.

Earthenware syphon traps may be used in connection with such waste water, and water from rain-water pipes, surface water from backyards, courts, and streets. As a rule, however, special modifications are used.

In view of the large quantity of grease and sand often present in the waste water from kitchen sinks it is advisable to use a special form of trap (*grease trap*) to prevent the grease at once passing through the trap and blocking the drain beyond. One form of grease trap is a stoneware syphon with a large wide descending portion which contains a large quantity of cold water. Hot water containing grease and sand is cooled on entering the trap, the grease solidifies and rises to the top; the sand sinks to the bottom. These may both be removed every second day by hand. If the trap be connected with an automatic flush tank the sudden inrush of a large quantity of water propels the fat through the trap and rushes it along the drain without allowing it to adhere to the sides of the pipe. The sand, in any case, must be removed by hand through a special opening in the lower part of the trap.

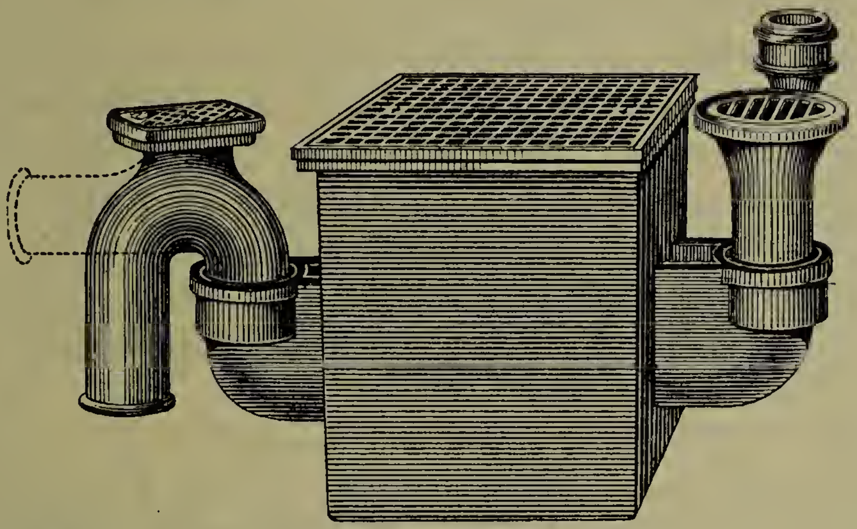
FIG. 57.—Grease trap. Shallow depth only required at outlet below ground level.

In the case of *street gullies*, special arrangements are necessary to prevent solid matter, such as stones and mud, from entering the sewer. The descending limb of the syphon is wide and deep, the lowest part accommodating a bucket provided with a flange round the top and fitting the sides

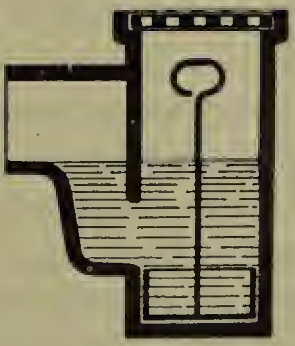
FIG. 58.—Yard gully trap with silt bucket.

of the trap accurately so as to prevent dirt passing into the bottom of the trap when the bucket is removed. Arrangements must be made for the regular cleansing of such a trap.

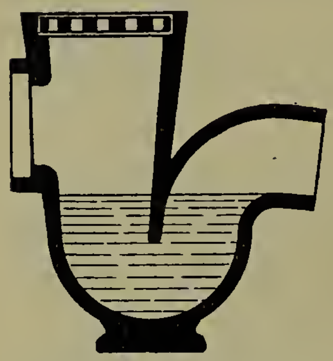
FIG. 59.—Gully trap with back inlet.

A type of trap formerly largely used in yards is the bell trap. This trap is apt to become choked from accumulation of deposit; the depth of the seal, usually only about $\frac{3}{8}$ of an inch, is insufficient; the seal is apt to be broken from evaporation of the water; the cover of the bell is often broken, and there is then direct communication with the air of the drain; finally it is a common occurrence, in the case of such traps, to find that the cover, if unbroken, has been removed, or has become displaced.

Waste-pipes—The Model By-law of the Local Government Board requires that "the waste-pipe from every bath, sink (not being a slop sink constructed or adapted to be used for receiving solid or liquid filth), or lavatory, the overflow-pipe from any cistern and from every safe under any bath or water-closet, and every pipe (used for) carrying off waste water," shall discharge in the open air, over a channel, leading to a trapped gully at least 18 inches distant; in other words be completely disconnected from the drain.

It is a common practice to discharge waste-water from sinks and baths in the upper parts of a house into the heads of rain-water pipes. This practice is objectionable, inasmuch as it leads to fouling of the whole extent of the rain-water pipe with grease and soapsuds, and nuisance is likely to be caused by the effluvia which escape from the rain-water pipe. The waste-pipe from the sink or bath need not, as a rule, be more than 1½ inches in diameter, and it should be carried down to, and made to discharge over, a gully in the open air.

The wastes from bath-safes and the overflow pipes of baths should be made to communicate with the open air as "warn-

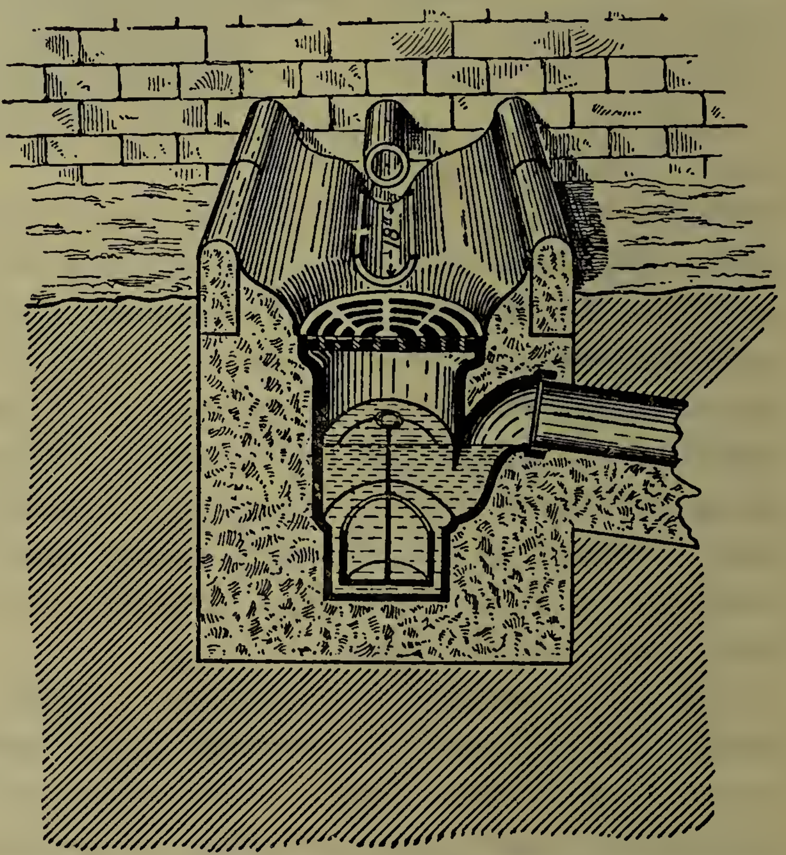
FIG. 60.—Trapped gully complying with the Model By-law. Discharge from waste pipe must lead to a trapped gully at least 18 in. distant.

ing pipes" ; the bath-waste may either be carried down and made to discharge over a gully, or else be connected with a sink-waste which terminates in this manner ; it is a good plan to carry a ventilating pipe from the upper end of the pipe receiving one or more bath- or sink-wastes, to a position well above and removed from attic windows.

The rain-water pipe should not be used as a soil-pipe or as a drain ventilator ; it should be caused to deliver over a properly trapped gully, and, where practicable, over one which also receives a sink, lavatory, or bath-waste, as a gully which receives the discharge of a rain-water pipe alone, is apt to become unsealed during dry weather.

Water-waste preventing cisterns should be used in connection with every w.c. They serve to disconnect the drinking-water supply from the water-closet basin, as well as to prevent the waste of water. There are many types of waste-preventing cisterns. The ordinary "valve-cistern," in which water only flows while the chain is held and the valve is thus raised from its seating, is open to objection, for the cistern is not likely to be always completely emptied under such conditions, and the closet may therefore be inadequately flushed.

The "syphon waste-preventer" possesses the advantage that one pull of the chain causes the discharge of the entire contents of the cistern ; moreover, no more water is permitted to escape until sufficient time has elapsed to allow the cistern to refill, and the chain is then again pulled. The amount of water in the cistern is often limited to two gallons, and in some waste-preventing cisterns even less is provided. Not infrequently, too, the aperture of the supply pipe of the cistern is made quite small, so as to prolong the process of refilling ; under these circumstances no one using the closet is likely to cause the contents of the cistern to be discharged more than once into the basin of the water-closet. When such conditions exist, waste of water is completely obviated, but proper cleansing of the water-closet basin is not so certainly secured. It has been contended that, with suitable appliances and proper flushing arrangements, a two-gallon flush is sufficient to cleanse the basin of the closet and to carry the contents discharged from it into the sewer, provided the drain is properly constructed and laid. Experiments show that, under the most favourable conditions, a two-gallon flush is generally sufficient, though there is, as might have been expected, greater security when 2½ or 3 gallons of water are used. There is thus undoubtedly advantage in providing for the waste-preventing cistern to contain at least 2½ or even 3 gallons of water, and the arrangement should, moreover, be such that the cistern rapidly refills, and can be emptied a second time should this be found necessary.

The action of a water-waste preventing cistern can be readily understood by studying Fig. 61. The water enters the cistern and rises between the inner and outer dome; when the water reaches the top of the inner tube the whole contents of the tank are discharged by syphonic action; the ball then falls and allows the cistern to be refilled.

Such cisterns should be placed at least 4 feet above the closet basin in order to obtain sufficient head of water. The pipe leading to the pan should be as free from bends as possible.

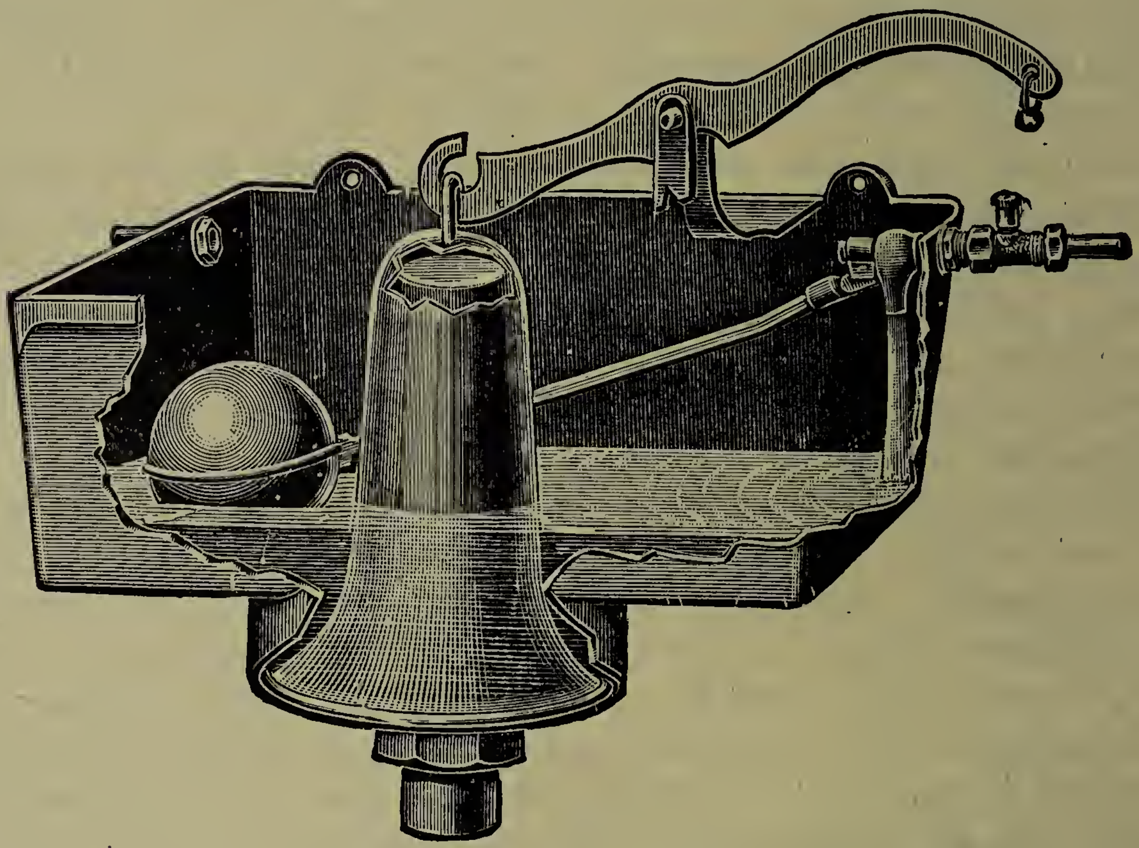

FIG. 61.—Lotus valveless syphon waste-water preventer.

Slop sinks are used in large houses, and in some of the Midland and Northern towns, where sufficient water for flushing water-closets is not available. The advantage of the slop sink is said to be that it effects economy in the use of water, inasmuch as the household waste-water can be utilised for flushing purposes. When slop sinks are employed they should be trapped and connected with the soil-pipe, just as a water-closet is; indeed, unless all the precautions deemed necessary in the case of water-closets are also taken with regard to them, they are likely to be a source of danger. Where the closet can be used for the reception of slops it is better to dispense with slop sinks altogether; if employed they should be provided with a safe having a waste-pipe which discharges into the open air, and it should be seen that they are kept clean and properly flushed.

VENTILATION OF HOUSE DRAINS

From what has already been said regarding the liability of drain air to become absorbed by the water of traps and to be subsequently given off on the house side of the trap, it will be seen that it is necessary to promote, as far as possible, the circulation of fresh air in the house drain, and to thus prevent the accumulation of gases of putrefaction in it. In order to ventilate the drain a suitable inlet and outlet should be provided, and, with a view to bringing about a flow of air from the one to the other, there should be a difference of level between the inlet and outlet openings; moreover, one of these openings should be placed at the head of the drain, and the other should be situated as near as possible to the point of communication of the drain with the sewer. In this way the air of the whole extent of the drain is continually renewed by ventilation. There is advantage in arranging that the flow of air through the drain shall be in the direction of the flow of the drain contents, if this is practicable.

The Model By-laws of the Local Government Board make the provision of two untrapped ventilating openings to the drain compulsory, and require that one of two alternative arrangements shall be adopted:—

(*a*) In the case where there is an open space belonging to the building and in front of it, the first of these two methods can be employed. The arrangement specified is that " one opening, being at or near the level of the surface of the ground adjoining such opening, shall communicate with the drains by means of a suitable pipe, shaft, or disconnecting chamber, and shall be situated as near as may be practicable to the trap . . . provided between the main drain, or other drain of the building and the sewer. . . . Such opening shall also in every case be situated on that side of the trap which is the nearer to the building. The second opening shall be obtained by carrying up, from a point in the drains, as far distant as may be practicable from the point at which the first-mentioned opening shall be situated, a pipe or shaft vertically to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to a height of less than 10 feet." This second opening can be provided, in those cases in which the soil-pipe is situated at the head of the drain, by carrying such soil-pipe well up above the eaves of the building, in a position removed from attic windows.

(*b*) The alternative arrangement, which can be adopted where the front of the building actually abuts upon the street, is described as follows:—" One opening shall be obtained by carrying up from a point, as near as may be practicable to the (intercepting) trap, . . . a pipe or shaft, vertically, to such a height and in such a manner as effectually to prevent any escape of foul air from such pipe or shaft into any building in the vicinity thereof, and in no case to

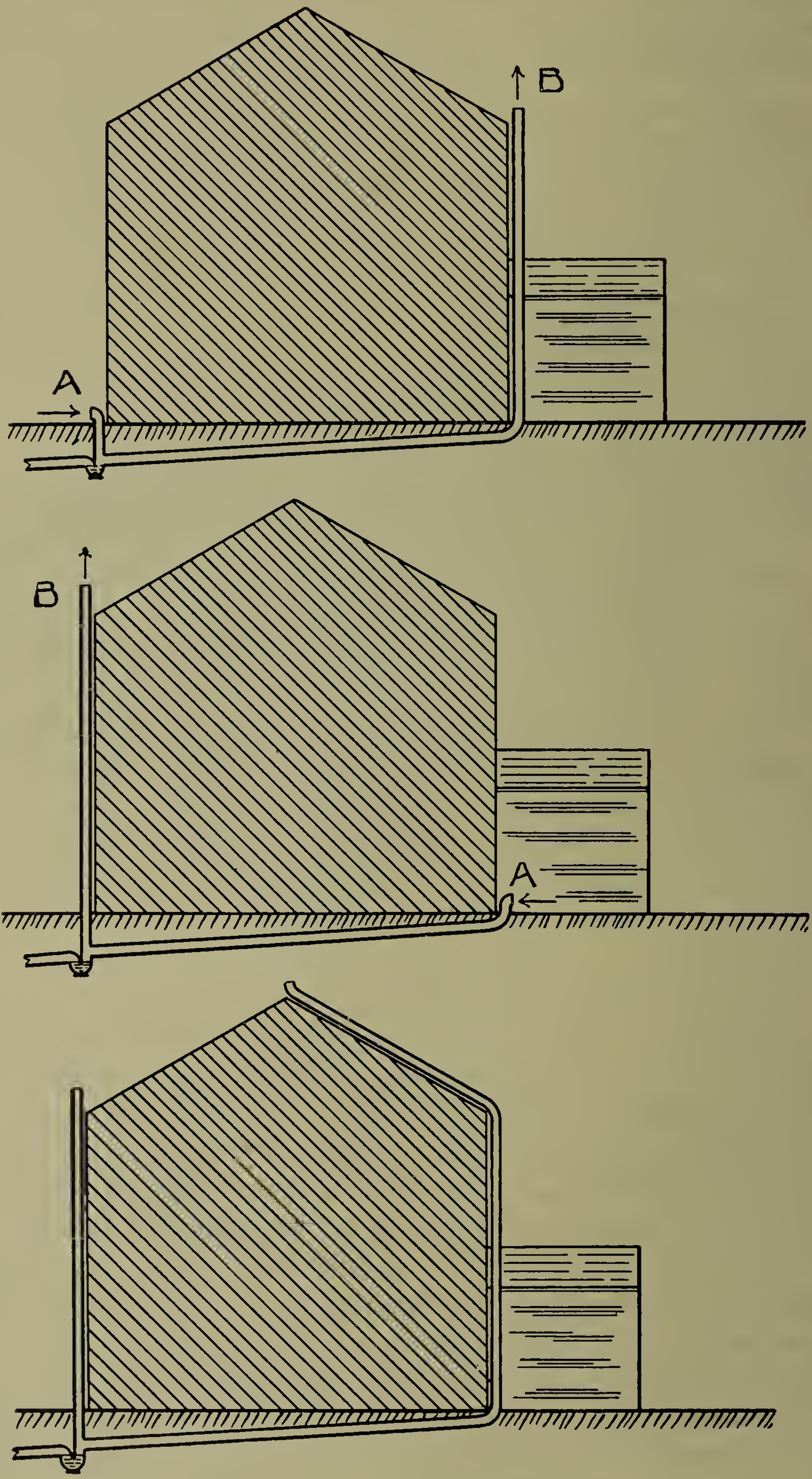

FIG. 62.—Different methods for ventilating house drains, according to Model By-laws.

a less height than 10 feet. Such opening shall also in every case be situated on that side of the trap which is the nearer to the building. The second opening, being at a point in the drains as far distant as may be practicable from the point at which such last-mentioned pipe or shaft shall be carried up, shall be at or near the level of the surface of the ground adjoining such opening, and shall communicate with the drains by means of a suitable pipe or shaft." In giving effect to this alternative arrangement it is sometimes possible to use a soil pipe carried up above the eaves, as already described, for the first ventilating opening, while the second ventilating opening may be formed by an untrapped gully in a back-yard.

The model by-law also provides that the pipe or shaft used, in connection with either of these arrangements, as a ventilating pipe, shall have a sectional area "not less than that of the drain with which it communicates, and not less in any case than the sectional area of a pipe or shaft of the diameter of 4 inches." It further specifies that "no bend or angle shall (except where unavoidable) be formed" in any such ventilating pipe, and it provides that a grating or cover, for the purpose of preventing any obstruction, shall be placed over every ventilating opening, such grating or cover to be so constructed and fitted as to secure the free passage of air, by means of a sufficient number of apertures, of which the aggregate sectional area shall be not less than that of the pipe or drain.

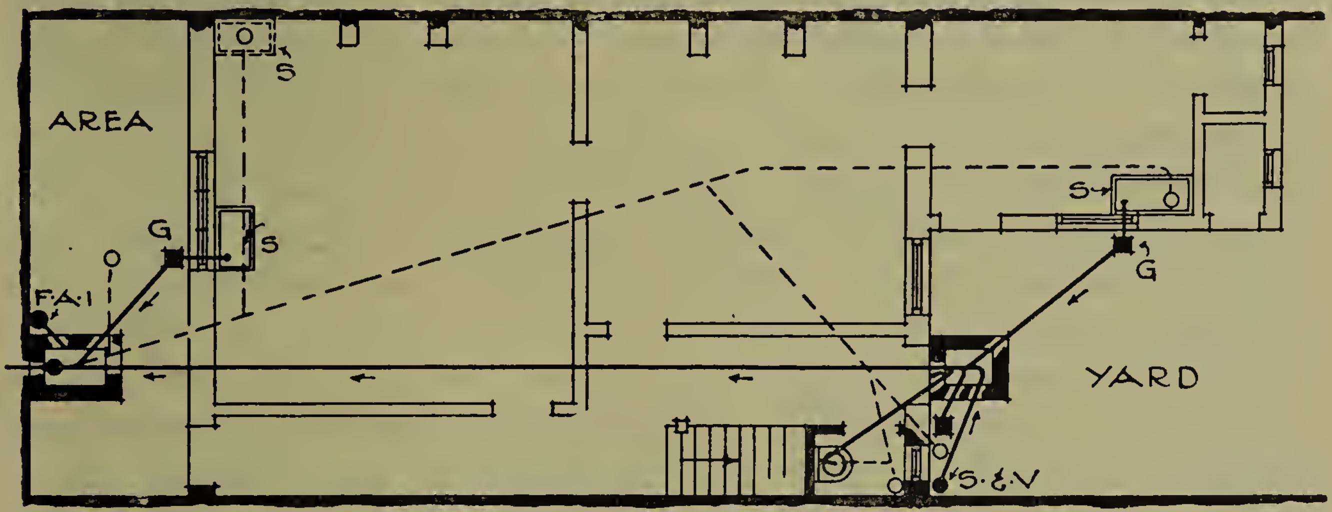

FIG. 63.—Good and bad drainage.

Plan of basement of town terrace house showing (1) old drains by broken lines with gully traps and soil pipe inside house and absence of means of access and interception from sewer; and (2) new drains by firm lines with traps and soil pipe outside building, interception from sewer, means of access and ventilation.

G = Gully trap. F.A.I. = Fresh air inlet. S = Sink. S. & V. = Soil and ventilating pipe.

Having regard to the extent to which bends or angles in ventilating pipes interfere with the passage of air, it is obvious that such obstructions to ventilation should, as far as possible, be avoided. Again, the necessity of providing a ventilating pipe of calibre equal to that of the drain which it ventilates, is apparent. It was, a few years ago, no unusual thing to find ventilating pipes of ridiculously insufficient size fitted in connection with house drains. It is a common practice for the lower or inlet opening to a drain-ventilating system to be provided with a mica flap, with a view to preventing the escape of drain air from the opening, while permitting fresh air to enter the drain; these flaps are, however, in practice, often found to be out of order, and if the ventilating opening be sufficiently remote from the windows of living rooms, and placed in a situation in which the escape of drain air is not likely to cause complaint, it is probably better to omit the flap.

DRAIN TESTING

All drains constructed in connection with new houses are tested either by an official of the local authority belonging to the Health or Surveyor's Department. New drains are invariably tested by applying the water test, the outlet of the drain being first plugged and the drain then filled with water to the level of the highest gully or other inlet; any intermediate opening at a lower level will, of course, also require to be plugged. The drain must be allowed to remain charged with water for at least half an hour. In laying new drains this test should be applied from time to time, as the several lengths of drain are completed. In testing a house-drainage system the lower end of the drain may be plugged at the point where it enters the disconnecting chamber, if there is one, or it may be necessary to open up the ground in order to expose the drain. Drain bags made of indiarubber or waterproof canvas are best adapted for plugging drains.

Properly laid stoneware drains should stand a pressure of 4 to 5 lbs. to the square inch; sometimes in applying the water test the level is found to slowly sink, although no actual defect can be discovered. This may be due to imperfect plugging of the drain, to the fact that the pipes are not wholly impervious to water (such "sweating" pipes should not be used), or to the occlusion of air in branch pipes or drains, as the drain is filled with water, and subsequent absorption of this intercepted air. This last-named contingency may be provided against by passing a bent pipe through the trap to allow of the air escaping, so as to ensure the whole length of the pipe tested being filled with water.

To ascertain the condition of older drains the smoke test is often used, a smoke machine being employed to pump smoke, from oily cotton-waste or other material, into the drain. In employing this method comparatively little pressure is brought to bear upon the drain, and the test is not, therefore, sufficiently searching, at any rate for drains laid within buildings. Defects in old drains may be detected by means of certain olfactory tests, *e.g.*, by pouring oil of peppermint down the highest water-closet, and then flushing with hot water, or by the use of "grenades," etc., charged with a mixture of assafœtida and phosphorus, which gives rise to a readily appreciable odour on being brought in contact with water. Such tests ought not to be applied to new drains, as they only reveal gross defects.

The pneumatic test, in which compressed air, supplied from a force pump, is employed, possesses the advantage that the pressure applied is uniform; whereas, in the water test the lower part of the drain is subjected to greater pressure than the upper part: it, however, does not indicate the position of any defect.

Sewers—The brick sewers originally constructed were designed to drain the subsoil as well as to carry away sewage; hence they were not made of impermeable materials, and not only did subsoil water enter them, but sewage matter was also able to escape from them. Further, they were constructed in such a way as to favour the accumulation of deposit.

When new sewers are to be laid down the first point to be settled is whether the sewer containing foul water shall be utilised to carry away the rain-water or not. The main disadvantage of admitting the rain-water (combined system of sewerage) is that in times of heavy rainfall very large volumes of storm-water enter the sewers; although some of this can be diverted by means of storm overflows a large proportion passes to the sewage works and has to be dealt with there. In the course of an hour or so the volume of sewage + storm-water may be as much as twelve times the ordinary flow of sewage for the particular time of day. Other disadvantages are that in hilly districts unless frequent storm overflows are provided the flushing of the large sewers required would be a source of difficulty in dry weather; grit and small gravel finds its way into the sewer from the street gullies and may cause partial or complete obstruction unless systematically removed. Street gully traps often become unsealed in dry weather and allow of the escape of sewer gas. Although an increased initial outlay is required the modern tendency is to keep most of the rain-water out of the sewers (partially separate system)—rain falling on the pavements, street surfaces and front portions of the roofs of houses passes into the street gullies and thence into a separate surface water sewer. Very rarely is the entirely separate system adopted; in this the water from back yards and the back portion of the roofs of houses is also separated from the sewage, thus requiring two sets of house drains for each house, one line for the front, the other for the back. In very large towns it may often be advisable to retain a combined system of sewers for the densely populated and often insanitary areas while providing the partially separate system for the suburbs and also for all new streets. The sewers must be large enough to cope with heavy downfalls of rain otherwise after heavy thunder storms the sewers are liable to be unduly burdened and flooding of low-lying streets and basements occurs.

To keep the cost within reasonable limits, even in the partially separate system of sewerage, relief must be provided at certain points in the sewers in the form of specially constructed outlets—storm overflows.

Local storm overflows relieve tributary sewers before they become overcharged; in this way the provision of an unnecessarily large outfall sewer out of proportion to dry weather requirements is avoided.

Main storm overflows are those placed on the main outfall sewer or sewers so that the volume of liquid reaching the sewage purification works shall not exceed a given volume—usually expressed in terms of the dry weather flow. The ordinary type of storm overflow consists of a manhole on a line of sewer containing a weir over the sill of which the water in the sewer flows when it has reached a certain depth (or weight); the height of the sill is such that the contents of the sewer pass over the sill when the dilution of the sewage has reached the required weakness.

Modern sewers, up to 18 inches in diameter, are generally made of well-glazed stoneware or iron pipes, and are circular in section. A sewer of more considerable dimensions is, as a rule, constructed with well-burnt impervious bricks set in Portland cement. The larger sewers are generally egg-shaped in section, as this form offers great resistance to external pressure, and possesses the manifest advantage that, when the volume of sewage is small, a maximum scouring effect is secured, there being less contact of the liquid with the containing walls, than would be the case if the sewer were circular in section. The floor of the sewer should be perfectly smooth and suitably curved. Stoneware blocks are often employed in this part of the sewer.

The gradient of the sewer should be designed to give a velocity of not less than 2½ feet per second in sewers up to 24 inches diameter; for larger sewers, a velocity of 2 feet per second is considered sufficient. It is very common to find sewers of far too large a diameter used for small gradients in the belief that the velocity of flow is thereby increased. If the hydraulic mean depth of the sewage flowing in the sewer were increased thereby the velocity would be increased, but it is not. Sewers of 6 or 7 inch diameter are now frequently used when a few years ago one of not less than 9 inches would have been used.

A simple formula for calculating the discharge from sewers is

$$V = 55\sqrt{2DF}.$$

Where V = velocity in feet per minute.
D = hydraulic mean depth.
F = fall in feet per mile.

If A be the sectional area of the fluid, $V \times A$ gives the discharge in cubic feet per minute. The "hydraulic mean depth" to which reference is made above is the sectional area of the current of fluid divided by the wetted perimeter. In the case of circular pipes the "hydraulic mean depth" is equal to one-fourth of the diameter, whatever be the sectional area of the fluid running in the pipe. In egg-shaped sewers the "hydraulic mean depth" varies according to the level of the sewage flowing in them. In the case of sewers constructed on the ordinary plan, in which the transverse diameter is two-thirds of the vertical diameter, the "hydraulic mean depth," when the sewer is running full, is ·2897 multiplied by the transverse diameter; when running two-thirds full, ·3157 multiplied by the transverse diameter; when running one-third full, ·2066 multiplied by the transverse diameter.

The junction of small sewers with larger ones should always be made in such a way that the sewage enters the larger sewer in the direction of flow; moreover, the points of junction of drains with sewers, or of small sewers with large sewers, should be so arranged as to prevent the "backing up" of sewage into the smaller pipes when the large sewer is running full.

In flat districts where the sewers must be laid to a flat gradient unless adequate automatic flushing tanks are provided the sewer cannot be kept clean or free from deposit. (Very little reliance is to be placed upon the use of water carts for flushing sewers.) These automatic tanks need frequent supervision to see that the water is flowing in.

Ventilation openings should be provided at frequent intervals. In the case of openings in the roadway it is commonly stated that the distance between the ventilators should not exceed 100 yards. In many streets these openings are placed in the middle of the road, directly over the sewer; in streets in which there is much traffic access to manholes is often provided from the pavement; in narrow thoroughfares, and at the dead-ends of sewers, ventilating shafts, carried up so as to permit of escape of the sewer air at a point sufficiently removed from windows, may be employed instead of surface ventilators.

Sometimes sewer ventilators are connected with factory chimneys, but this course is not to be recommended; it has been found that the aspirating effect of the chimney is only appreciable for a short distance in the sewer, for while much air is sucked in at openings in the near neighbourhood of the chimney, the effect produced has only been quite local. Again, this method of ventilating sewers is likely to lead to suction of water from the traps of house-drains near the chimney.

Pipes have also been carried up through street gas lamps with a view to exposing the sewer air to the gas flame.

Deodorising materials have also been recommended in cases where nuisance is experienced in connection with sewer ventilators, but cannot be regarded as a satisfactory means of disposing of the difficulty. Where the sewers are well constructed, properly flushed, and have a sufficient fall, deodorising devices are unnecessary; in any case their adoption only palliates and does not go to the root of the mischief.

The flow of air in sewers is in part determined by the flow of the sewage, which, to some extent, draws the superincumbent air along with it. Again, the difference in the temperatures, inside the sewer and in the roadway, tends to produce interchange of air through sewer ventilators.

The air in the sewer is usually warmer than the air outside, and on this account, and because it is saturated with moisture, tends to rise through ventilating openings in the roadway, while the colder external air enters the sewer. Further, the discharge of warm liquids into the sewer, and variations in the volume of sewage at different times of the day, and especially during periods of rainfall, favour the displacement of sewer air. Finally, variations of barometrical pressure, and the aspirating effect of winds blowing into or over openings communicating with the sewer, are factors which influence sewer ventilation.

The air of well-ventilated sewers differs little in chemical composition from that of the ordinary atmosphere. It has been shown, by Laws and Andrewes, that the bacteria of sewer air are for the most part those of the surrounding atmospheric air, and that there is little tendency for the bacteria of the sewage to obtain access to the air of sewers. Horrocks[1] showed that under natural conditions typhoid bacilli might be carried by sewer air long distances and escape at manhole and soil pipe openings. It is evident that these bacilli are very few in number. Winslow[2] found that mechanical splashing may produce a slight local infection of the air in immediate contact with the spray, but the infection extends only for a very short distance and does not persist for more than a minute or two; sewage bacteria were only found four times in 200 litres of air in the presence of such mechanical spraying.

In ill-ventilated sewers, however, the contained air, on chemical analysis, has been found, in particular instances, to present marked deviation from the constitution of the ordinary atmosphere. In certain instances men, who have entered foul sewers, in which there was much putrefying sediment and in which the absence of ventilation had brought about accumulation of gases of decomposition have been attacked with acute symptoms of poisoning (headache, vomiting, purging, etc.), and a fatal result has in rare cases been known to occur.

The air of a choked sewer in Paris was found to contain nearly 3 per cent. of sulphuretted hydrogen and only 13·8 per cent. of oxygen.

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[1] Horrocks, "Public Health," 1907, xix, p. 495.

[2] Winslow, Rep. to the San. Comm. Nat. Ass. Master Plumbers, 1907–9.

Sulphuretted hydrogen [1] is the most dangerous of the gases present, it is fatal in quite small quantities and the ill-effects from non-fatal doses are cumulative. The oxygen present in the air above the sewage is reduced by absorption during the bio-chemical changes, and is reduced by dilution with the gases (carbon dioxide, marsh gas, hydrogen, etc.) given off during these changes. In manufacturing districts a further dilution is caused by the discharge of trade wastes containing ammonia or steam.

Sewage Disposal—*The Discharge of sewage into the sea or into the estuary of a large river* has been adopted by numerous local authorities; provided that the outfall is below low-water mark of the lowest tide, that the local currents are such as to carry the sewage out to sea, and that the discharge is effected at suitable times, the system is not productive of complaint. Float observations have been made, in particular instances, with a view to determining the direction of the local currents, and the point at which the sewage outfall may with advantage be placed. Difficulty is experienced of course, from the fact that the sewage is continually flowing, and that it can only be discharged at certain states of the tide.

An example of the manner in which these difficulties are met in a seaside town follows. The sewage is collected in storage tanks when tide-locked, and on being released is passed through two screens, the first of which has a $\frac{3}{4}$ in. mesh, the second a $\frac{5}{16}$ in. mesh. These screens are fitted with a series of rakes and the screenings are conveyed, by means of compressed air, back to the pumping station where they are emptied into pan carts and finally deposited on land on the outskirts of the borough.

The distance of the sewer outlet from the foreshore is 900 yards and sewage is only discharged at ebb tide until within an hour of its return, approximately five hours.

The risk attendant upon adoption of the method of disposal in question is, of course, much greater, where tidal estuaries are concerned, than it is in places situated on the sea shore; in tidal estuaries the tendency usually is for the sewage to be brought back by the incoming tide, and for a contaminated "sewage zone" to be formed in the estuary.

Discharge of Sewage Effluents into Streams. In the case of inland towns the problem of sewage disposal is far less simple; to prevent pollution of streams a purification of the sewage is required before the material can be allowed to pass into the stream.

The Rivers Pollution Commissioners laid down the following standards as being those with which a sewage effluent discharged into a river should comply:—

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[1] See "Anti-gas measures in sewers and sewage tanks," Whitehead, "Journal of Municipal and County Engineers," 1921, p. 368.

Maximum Impurity in Parts per 100,000.

Dry mineral matter in suspension.	Dry organic matter in suspension.	Colour.	In solution.					
			Organic carbon.	Organic nitrogen.	Any metal except calcium, magnesium, potassium, or sodium.	Arsenic.	Chlorine.	Sulphur as H_2S or sulphate.
3	1	Any colour in one inch stratum in a white vessel	2	0·3	2	·05	1	1

The "organic ammonia" is often appealed to as a test of a good effluent; it should not exceed ·15 per 100,000. The "oxygen absorbed" in four hours at 80° F. ought not to amount to more than 1·5 parts per 100,000. The percentage of dissolved organic pollution removed, expressed in parts of permanganate of potash reduced, is a criterion now commonly applied. A satisfactory effluent should be devoid of fæcal odour, and not be liable to undergo secondary decomposition.

All purification is relative, and since local circumstances differ widely as regards different towns and rivers it follows that a lesser degree of purification may suffice in one case whilst a much higher degree of purification may be demanded by another case. The Sewage Disposal Commission (Fifth Report, p. 9) say, "The two main questions, therefore, to be considered in the case of a town proposing to adopt a system of sewage purification are, first, what degree of purification is required in the circumstances of that town and of the river or stream into which its liquid refuse is to be discharged; and, second, how the degree of purification required can, in the particular case, be most economically obtained."

During the cool months of the year a stream can receive more pollution without becoming a nuisance than would be possible in hot weather. This is due to the oxygen of the atmosphere being absorbed to a greater extent at lower temperatures; at 32° F. one litre of water holds 10·2 cc. in solution; at 68° F. it holds 6·4 cc. Also, at the lower temperature the rate of bio-chemical change is slower, most chemical actions including photosynthesis double their velocity for each 10° C. (18° F.) rise of temperature. An increased river flow in winter causes more dilution and propels polluted waters away more rapidly.

During the hot months pollution is checked by the rapid growth of aquatic plants and algæ; these have the power of abstracting ammonia and nitrates from the water. Also much oxygen is given off by these aquatic plants; in sunlight, water flowing over dense beds of plants contains as much as 12 cc. per litre.

The water-supply per head of the population varies considerably in different towns and as this water dilutes the sewage matter the amount of water supplied exercises a very considerable influence on the strength of the sewage. Since the purification of sewage is to a large extent a process of indirect oxidation through the agency of bacteria, the strength of a sewage can best be measured by ascertaining the amount of dissolved oxygen taken up during the complete oxidation of the organic and ammoniacal matter in the sewage. The rate at which oxygen is taken up is also of importance as it furnishes information as to the character of the organic matter. The standard usually adopted is the amount of oxygen absorbed in four hours at 80° F. from an eighth-normal solution of potassium permanganate rendered acid with dilute sulphuric acid. The following table shows the composition of various sewages:—

STRONG OR VERY STRONG SEWAGE [1]

		Parts per 100,000.		
Water Supply, etc.	"Strength of Sewage."	Ammoniacal Nitrogen.	Oxygen absorbed in 4 hours.	Suspended Solids.
Slopwater town—10–15 gallons per head. Partially separate system of sewers . . .	200–230	6·0	25	40
Do. Do.	175–200	7·5	20	40
W.C. town—25–30 gallons per head. Separate system of sewers	160–170	9·0	17	40
SEWAGES OF ABOUT AVERAGE STRENGTH				
W.C. town—30 gallons per head. Some subsoil water in sewage	100	4·0	10–12	28–30
WEAK SEWAGES				
W.C. or slopwater town—25–30 gallons per head. Much subsoil water in sewage . .	60	2·5	7–8	20

As to the methods adopted to purify the sewage the report of the recent Commission on Sewage Disposal shows that artificial filters, contact beds, and land treatment are most frequently employed. Common to many methods is the preliminary removal of large lumps of solid matter, including solid fæces, floating in the sewage, by means of bar screens; this solid matter is usually removed to a dust destructor or buried in any land available for the purpose. Heavy particles of grit pass through the screens; they are caused to deposit either in grit chambers (detritus tanks) or settling tanks.

For the proper appreciation of the sewage purification problem a clear understanding of the physical and chemical nature of sewage is necessary. Sewage consists first of coarser and finer visible particles, which can be removed by sedimentation, secondly, of matters causing turbidity, not visible to the naked eye, but visible under the microscope and of still finer matters and of matters in colloid solution both of which are visible under the ultra-microscope and are capable of being coagulated or oxidised and dissolved by chemical or bio-chemical treatment, and thirdly of matters in true solution which are invisible and which when alterable can only be altered by chemical or bio-chemical treatment. In the early days sewage treatment was an affair mainly of mechanical separation plus treatment with chemicals. In recent years the attempt has been made to make the best possible use of the living organisms, ærobic or anærobic, which are abundantly present in the sewage itself. Thus the "septic tank" aims at breaking up the complex organic compounds under anærobic conditions, as a preliminary to final oxidising processes designed to secure an inoffensive effluent. More commonly, nowadays ærobic treatment is carried out from the start, organisms which flourish with free supply of atmospheric oxygen being relied upon to bring about the desired changes in the sewage. This oxidising treatment may be effected by "contact beds" or by spraying the sewage or an admixture of sewage or "activated sludge" by means of distributing arms over filter beds, and thus allowing the organisms of the sewage itself, under conditions of intensive aeration, to carry out the purification necessary. Colonies of organisms are under these circumstances grown upon the particles of filtering material upon which they form a humus-like coating, or alternatively they may become freely distributed throughout the sewage. The humus into which the solid and colloidal matters of the sewage becomes converted constitutes "activated sludge," a brownish sediment with an earthy inoffensive odour which has a high nitrogen content, even 4 per cent. of the dry matter.

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[1] See Kershaw, "Purification of Sewage," p. 33.

It is thus obvious that the following kinds of treatment are possible, (1) sedimentation, (2) coagulation, (3) oxidation, and that the two latter can be effected by purely chemical or preferably by biochemical means. As to sedimentation some use of "detritus pits" is commonly necessary.

The sewage either passes through the settling tanks in a continuous flow or a full tank is allowed to remain quiescent for two to three hours; the suspended matter is deposited on the floors of the tanks and removed from time to time as sludge.

Where coagulation and oxidation are effected by purely chemical means this is generally done merely as an emergency measure for the purpose of "deodorisation." Nowadays coagulation is usually brought about in conjunction with oxidation by Nature's own method, viz., by bio-chemical means. The active agents are already present in the sewage, but they must be greatly increased in numbers by supplying oxygen in sufficient amount, either by blowing it in a fine state of division through the sewage to be purified, or by spraying the sewage, or preferably a mixture of sewage and activated sludge, over the filter beds.

Chemical Precipitation—Numerous analyses given by the Rivers Pollution Commissioners showed that the chemical methods in use at the time of their report only removed, on an average, about 90 per cent. of the suspended matters of sewage, and 36 per cent. of the organic nitrogen dissolved in it. (The organic nitrogen in sewage is generally about 2 parts per 100,000.)

While chemical precipitation alone cannot be expected to produce a tank liquor suitable for discharge in large volumes into a river or stream of small volume it frequently forms a very valuable preliminary to modern filtration processes, especially where very fine filters are used. It prevents smell during the treatment of sewage containing liquids from breweries and tanneries or wool-scouring. The disadvantage is the production of a large volume of sludge. The chemicals most generally in use are milk of lime which requires mixing machinery and blocks of aluminoferric; both may be used in conjunction. Copperas is also used with lime. Sulphuric acid is employed for sewage containing much wool-scouring refuse, as a means of separation of fat for recovery.

The sludge question is the *bête noir* of all sewage disposal systems; the chief difficulty is not how to produce a satisfactory effluent but how to get rid of the sludge. Sludge consists mainly of the suspended matters removed from the sewage; these are largely mineral or cellulose. The greasy matter present derived from soapsuds and the waste water resulting from cooking processes (and occasionally from wool-scouring works) hinder its use for manure; the soil after a time is made impervious to air and water. In the raw state sludge is difficult to deal with by reason of the amount of moisture present and of the putrescible substances which soon cause a nuisance. The slowness of drying and the smell produced are reasonable objections to the old methods of running sludge in the liquid state into lagoons; again the sludge has ultimately to be removed from these lagoons. Sludge presses reduce the moisture present and produce cakes which can be easily handled. Lime is usually added unless the grease present is to be extracted. The cake has some slight manurial value and is acceptable to farmers; it can be also used for filling in waste land, if covered with soil or if the grease has been removed from the sewage, the cake can be burnt in dust destructors. Waste material such as house refuse, street sweepings, etc., are at times mixed with liquid sludge. Shallow burial of sludge is one of the best methods of disposal where plenty of land is available.

Although scientifically incorrect, dumping in the sea is the mode of disposal adopted by practically all large towns within easy reach of the sea.

BIOCHEMICAL TREATMENT

As we have seen in this method of treatment of sewage, the aim is not to arrest but to favour decomposition; endeavour is made to so control the sequence of changes, however, as to prevent nuisance, and yet attain the desired purification. Various forms of apparatus are used for the purpose.

Contact beds consist of watertight tanks provided with inlets and outlets for tank liquor, and filled with hard durable material such as clinker, coke, broken stone, etc. The tank liquor is run into the contact bed until the liquid is almost level with the top of the contact material and left in contact for a certain period after which it is run off and the bed allowed to stand empty for a certain time. The first contact bed effluent is usually passed through a second and very occasionally a third bed. Finer material is used in the successive beds; as the process advances the amount of suspended matter becomes less; by using fine material a much greater combined surface area of particles is secured and a comparatively larger proportion of colloidal matter removed.

Not only bacteria but also worms, larvæ, insects, etc., act as purifying agents; these serve by breaking up the larger solids. The bulk of the work of purification takes place when the bed is resting, the generally accepted theory as regards the nitrogenous matter being that the ammonia is extracted from the liquid during the period of contact and oxidised during the period of rest, and that the resulting nitrate and nitrite are diffused through the liquid of a subsequent filling. All the ammoniacal nitrogen, however, does not appear in the effluent in the oxidised state, for there is always loss of nitrogen as nitrogen gas, during the process.

A mature contact bed withdraws more suspended matter from the sewage than a new bed similar in every other way, so that the withdrawal of suspended and collodial matter is evidently more than a simple mechanical effect.

Like percolating filters, contact beds take some time to ripen before the material becomes coated with slimy growths and yields satisfactory results. The presence of subsoil water favours the formation of this growth.

Effluents from single and double beds usually contain considerable amounts of suspended solids; as these are almost always putrescible these solids must be removed before the effluent leaves the works. If a settling tank is provided for this purpose it overcomes at the same time one of the greatest drawbacks of the contact bed system—the mixing of the turbid and putrescible liquid which passes out first when the bed is emptied with the subsequent purer effluent. When the beds have become mature the treatment of sewage in contact beds is remarkably free from smell.

Percolating Filters—In a percolating filter the sewage liquor is applied continuously to the filter and passes through and away from the filter continuously. The most favourable conditions for oxidation of sewage liquor are provided when it is sprinkled in a fine spray over the surface and trickles slowly through the filter with ample aeration, the air necessary for aerating purposes being carried down through the filter by the flow of sewage. Fine material filters require careful working and resting if the body of the filter is to remain well aerated for any length of time. The addition of common salt to sewage has demonstrated that the average duration of contact in a percolating filter is usually several hours; although when sewage liquor is applied to a filter an effluent passes out within five minutes, an admixture has taken place with the fluid held up in the filtering material and a small part only of the fluid recently added is present in the effluent.

The chief matter for attention in distributing the liquid over the surface of the filter is that the distribution should be uniform; if this is secured each portion of the filter receives an equal dose and in consequence the rate of filtration is even and the duration of contact of the liquid with the filtering material a maximum for the particular rate of treatment adopted. The degree of purification produced by a percolating filter varies with the average length of time occupied by the tank liquor in passing through the filter; the size of the material in consequence exercises a marked influence on the quality of the effluent.

Septic Tank—In 1895, Mr. Donald Cameron, the City Surveyor of Exeter, introduced the "septic tank." He applied the principle of subjecting sewage to preliminary treatment in a receptacle covered to exclude the light and, as far as possible, the air. The incoming sewage was delivered below water-level, and the outlet was also submerged; the passage of material through the tank was, moreover, slowly accomplished, and disturbance of the upper layers of the liquid was, as far as possible, avoided. Under these circumstances it was found that very little sludge collected in the tank, only a thin layer of black earthy matter being formed. A scum develops on the surface of the sewage; and here ærobic micro-organisms are, no doubt, actively at work, while, in the deeper layers in the tank, anærobic organisms may be assumed to be carrying on the process of liquefaction of suspended matter. On leaving the septic tank, through an opening placed, so as to exclude the surface scum, somewhat below the level of the sewage in the tank, the effluent is made to flow in a thin stream into an "aerator," and thence, by means of automatic alternating gear, it is turned on to first one, then another, of a series of coke-breeze filters or on to land.

Contrary to former belief it has been shown that digestion of solids is by no means complete, the number of pathogenic organisms is unaltered, and septic tank liquor is not more easily oxidised by the filters than other tank liquors. The value of septic tanks lies in the settlement and partial liquefaction (30–40 per cent.) of suspended matter in the sewage and the equalisation in the strength of the sewage brought about by the relatively long stay (24 hours) in the tank. Difficulties have not infrequently arisen from the smell; these have been reduced by covering the outlet channels. The smell incurred by the use of septic tanks has given rise to the introduction of slate beds, installations for the preliminary treatment of crude sewage; these have proved to be satisfactory. The beds are about 4 feet deep and consist of layers of refuse slates horizontally kept about 2½ inches apart by small slate slabs. The crude sewage is retained for two hours; the clear and inodorous effluent is applied to contact beds of fine clinker. Very little silt is deposited on the slates.

A new biological method of dealing with sewage has been recently developed. Mr. Haworth has established at the Sheffield Sewage Works a *bio-aeration plant* for dealing with the Tinsley sewage, 500,000 gallons a day. The sewage is introduced at the bottom of the circulating tank so as to ensure thorough mixing of the contents of the tank, it meets there sewage water and 25 per cent. of "activated" sludge. The tank is divided into eighteen channels by partitions which alternately fail to reach one end of the tank; a continuous circuit (¾ mile in length through the tank) can thus be brought about. Each channel has its paddle wheel which keeps up the velocity of the current and aerates the sewage. The paddle wheel makes waves which break over the baffle plate; the lip of air under the oncoming wave is locked in; also the surface of the wave exposed to the air is greater than the surface of the corresponding quantity of smooth water and an increased quantity of air is in contact with the atmosphere and more air is absorbed. The sewage entering pushes the treated sewage out into three settling tanks; one-quarter of the sludge is drawn off by syphonic action and pumped back into the circulating tank, excess sludge being drawn by a by-pass and sent to waste. Although the sludge still remains to be dealt with, it is much less in amount, being reduced by 30–40 per cent.; more is digested by the increased activity of the organisms in the sludge brought about by the aeration. The success of the process can be judged by the results obtained: suspended solids have never been found to exceed 3 parts per 100,000, the average figure for the quantity of oxygen absorbed from potassium permanganate in four hours is ·76 and the effluent is pumped into the river by the side of the farm to serve as compensation water.

The advantages of this new process are the reduction in the area of land required for the treatment of the sewage, the ease of control of the plant, the elimination of manual labour in sludging and the cost of upkeep of filters.[1]

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[1] See "Journal of Municipal and County Engineers," Aug. 27, 1921. The disposal of the sludge, however, is still difficult; it is more watery and thus more bulky than usual and more difficult to pump.

Land treatment of sewage is especially suitable for small towns and villages where suitable land is more readily available than in large towns. The best soils for sewage purification are found on the Bunter sandstone formation and consist of light porous soil containing only about 15 per cent. of clay overlying a subsoil of gravelly sand. The presence of fissures in chalk soils makes the purification uncertain, serious pollution of the ground water may occur. Since only a thin layer of topsoil is found on clay soils, the acreage of the farm must be very much greater if the soil is clay.

Tanks may be provided for preliminary sedimentation, but if much land is available it is more economical to convey the sewage direct to the land and allow the soil to deal with the suspended solids rather than introduce the difficulty of sludge. Two arrangements are used, often both at the same farm. In broad irrigation the sewage overflows the edges of carriers and gutters cut on the sides of gentle slopes, and is spread over the intervening land on which crops are grown ; the purified fluid reaching a drain at the bottom of the slope is carried to a stream. Under drainage is only exceptionally required. In " intermittent downward filtration," carriers convey large volumes of sewage to relatively small areas of land used in rotation ; the soil must be permeable. Under drainage is almost always a necessity. The land must be practically level and as a rule embanked to retain the sewage during filtration ; it is laid out in wide ridges and furrows, the ridges on which the vegetables are grown are from 4 to 8 feet wide. The sewage or tank liquor flows about a foot deep, and is drawn into the ridges by capillary action. A filtration farm need be only one-third the size of an irrigation farm. Sewage can only be applied to the land for a part of the day (6–12 hours) ; in addition the land every week or so requires prolonged periods of rest ; the total irrigable area of a farm must in consequence be considerably in excess of the area required for purposes of purification at any one time—five times as much in the case of surface irrigation and three times for filtration.

During land treatment much of the water present in the sewage is disposed of by natural processes—evaporation, soaking through the soil and the withdrawal of water from the ground by the roots of plants. The quantity of fluid leaving the farm as effluent is in consequence much less than that present in the sewage treated ; in hot weather there may even be no effluent.

The need of the land for a prolonged rest is shown by the surface becoming coated with a greyish-black sediment composed of algæ, and signs of grey growths and " ponding " ; grey growths also appear in the bed and sides of the channel streams carrying away the effluent and extend a considerable distance below the outfall. Land which has been overdosed with sewage for some time is termed " sewage sick." The trouble is probably due to the presence of an excess of suspended solids in the sewage ; these promote the growth of various kinds of algæ and add to the density of the filtering film. The land should be scarified and ploughed and allowed to stand for a short time for aeration; if found necessary the tank capacity should be increased to separate a greater proportion of the suspended solids. But it is the large volume of storm water arriving in times of heavy and continued rainfall that overtaxes the capacity of the land; the remedy is the provision of standby sedimentation tanks to deal with any excess over three times the dry weather flow, the tank liquor passing directly to the river.

In farms laid out exclusively for filtration the possibility of cropping is limited. When surface irrigation is used a variety of crops can be grown, Italian rye grass and mangolds being the most common; cabbage, kohl-rabi, peppermint and comfrey are also produced; lucerne flourishes on sandy soils; where the area under sewage is ample, market garden produce such as brussels sprouts, celery, carrots, beet and cauliflowers can be grown. The purification of the sewage however must always come before the crops. Cattle, including milch cows, have been reared on sewage farms with marked success.

The inquiries made by the recent Commission on Sewage Disposal elicited the advantages of this method of purification where the soil and subsoil are of a suitable character and the volume of sewage treated per acre is not excessive; it is one of the best means of producing a satisfactory effluent containing a minimum of suspended solids and with a low figure for the five days' oxygen absorption test. There is, however, risk of smell; the sewage farm must be a considerable distance away from dwellinghouses.

As regards cost the Sewage Disposal Commission in their Fifth Report say, "Assuming that really suitable land can be purchased at £100 per acre, land treatment of sewage is probably cheaper than artificial processes. The differences in cost are, however, small and it is evident that in deciding between the two methods regard must be had to local conditions.

"As a general rule, an effluent from good land properly worked contains practically no suspended solids, but this cannot be said of artificial filters, even assuming that settlement of the effluent in tanks is adopted. This might be a factor of considerable importance in the case of some streams."

Smell from Sewage Works.—Any smell from sewage works is worse in hot weather and is specially noticeable on calm days when there is much moisture in the air and a light breeze to carry the smell to houses near. The smell may originate from the settling tanks, percolating filters or from the sludge. When domestic sewage alone is treated in tanks if they are kept closed and not run for too long periods without sludging very little smell should occur. In hot weather the removal of sludge from the tanks gives rise to smell in the vicinity; brewery and tanning liquids are frequently a cause of more serious offence at these times even in winter; chemical precipitants such as lime, a useful remedy in ordinary cases, fail to lessen the smell caused by brewery refuse. The liability to cause a nuisance from smell is greatest when sewage liquor, especially septic tank liquor, is applied to percolating filters in the form of a fine spray, a very large superficial area of finely divided liquid is exposed to the air and often carried a considerable distance. During land treatment smell may arise from dirty carriers, land too heavily sewaged and especially from dirty land while drying off under a hot sun. Smell from the sludge while draining in lagoons or trenches prior to removal or trenching-in can usually be prevented by a light sprinkling of lime or bleaching powder. Sewage works are best situated in an isolated position, even if less expensive sites can be obtained near dwelling-houses.

Health of Sewage Workers—No convincing proof has yet been furnished of direct or widespread injury to health in the case of well-managed farms. The experience with regard to men working on sewage farms is that their health is particularly good; this applies to the casual labourers occasionally engaged on the farm as well as the ordinary staff who might be expected to become inured to any supposed ill-effect.

Typhoid fever has in a few cases been attributed to effluvia from these farms, but in one or two instances, in which the question has been carefully inquired into, it has transpired that the probable source of infection was the consumption, by the persons attacked, of sewage-contaminated water. The population living in the neighbourhood of well-managed farms does not appear to suffer from diseases which could be thought of as being caused by sewage effluvia: this is especially borne out by the experience of the Berlin sewage farms. In the early days of sewage farming it was anticipated that tape-worms and round-worms would obtain access to the human alimentary canal, to an increasing extent, as the result of the application of liquid sewage to land. Instances of infection traced to this source have not, however, been forthcoming, and this fact has been attributed to the alkalinity of the sewage, for the ova of these parasites naturally undergo development in an acid medium. In no instance has the consumption of vegetable produce from sewage farms, in this country, been definitely found to have produced disease in man, and when cattle are pastured on sewage farms, and their milk subsequently distributed, no harmful result has been observed. An epidemic of "entero-colitis," which occurred at an asylum in France, was attributed, in 1889, to *Trichocephalus*, which was supposed to have been communicated by consumption of vegetables watered with sewage water. The risk of contamination of water supplies derived from formations in which the existence of fissures may lead to pollution of deep wells, is one carefully to be borne in mind.

Treatment of Storm-water—The last Sewage Disposal Commission commented adversely on the use of special storm filters as suggested by the Local Government Board. Such an arrangement they hold causes injury to rivers by discharging into them large volumes of storm sewage containing an excessive amount of suspended solids. They advocate that provision should be made for filtering about three times the normal dry weather flow and that *settling* *tanks* should be used when there is an excess of flow over three times the normal quantity; these tanks should hold about one-quarter of the daily dry weather flow.

Sterilisation of Effluents

After the employment of the most suitable methods of sewage purification the effluent may still contain pathogenic organisms.

The fifth report of the Royal Commission on Sewage Disposal (1908) contains the following paragraphs:

304. "We observe that previous Commissions have reported that, of all the processes which were proposed for the purification of sewage, or of water polluted by excrementitious matter, there is not one which is sufficiently effective to warrant the use, for dietetic purposes, of water which has been so contaminated, and the 1868 Commission stated that, in their opinion, 'rivers which had received sewage, even if that sewage had been purified before its discharge, were not safe sources of potable water.' We, therefore, conclude that the framers of the Rivers Pollution Prevention Act, 1876, did not contemplate that local authorities should be required so to deal with their sewage that the rivers into which the purified sewage flowed might be regarded as safe sources of water supply, in cases in which the water was not to be filtered before distribution."

305. "In our opinion much the same position must be taken up to-day. Although the methods available for the purification of sewage are more numerous than when the 1868 Commission reported, our examination of a very large number of effluents from sewage farms, and from artificial filters of various kinds, shows that, although such effluents may be very good as judged by chemical and physical tests, they are generally liable to contain large numbers of micro-organisms of intestinal derivation, and that if such organisms are to be destroyed, or eliminated, the effluents must be subjected to some treatment additional to that which is ordinarily employed.

"We have carried out some experiments for the purpose of ascertaining the practicability of certain of the methods which have been suggested for the removal or destruction of these micro-organisms. These experiments, which are described in Houston's Report, Appendix IV, have shown that, while it would be practicable to render sewage effluents fairly pure, bacteriologically, the cost of the necessary additional treatment would be serious."

306. "Moreover, a false sense of security would be obtained by the adoption of further treatment unless, at the same time, storm overflows on sewers were abolished."

. . . .

309. "We are satisfied that rivers generally, those traversing agricultural as well as those draining manufacturing or urban areas, are necessarily exposed to other pollutions besides sewage, and it appears to us, therefore, that any authority taking water from such rivers for the purposes of water supply must be held to be aware of the risks to which the water is exposed, and that it should be regarded as part of the duty of that authority, systematically and thoroughly, to purify the water before distributing it to their customers."

310. "Apart from the question of drinking waters, we find no evidence to show that the mere presence of organisms of a noxious character in a river constitutes a danger to the public health or destroys the amenities of the river. Generally speaking, therefore, we do not consider that in the present state of knowledge we should be justified in recommending that it should be the duty of the local authority to treat its sewage so that it should be bacteriologically pure."

TRADE WASTES

Trade wastes [1] may consist of solids or liquids; as a general rule the bulk of trade wastes is in liquid form and consists of water used for trade purposes which carries various impurities both in solution and suspension. Although with the exception of waste liquors from tanneries and fellmongers' yards which may contain the spores and bacilli of anthrax, trade wastes do not contain pathogenic organisms, some contain poisonous substances injurious to cattle and fish. Even clean hot water such as condenser water may give rise to trouble by causing the death and subsequent putrefaction of water weeds, or if discharged into small streams by killing fish. The equable flow of trade wastes to sewers is very desirable; sudden heavy flows of waste to small sewage works are very difficult to deal with, especially if precipitants are used. If, however, the wastes are let off from a tank equably throughout the twenty-four hours such difficulties are very much lessened.

Trade effluents are usually discharged into streams throughout twelve hours of the day in contrast to the sewage effluents the discharge of which is spread over the twenty-four hours so that for equal quantities of effluent in the case of the manufactory the dilution given by the stream is only one-half that of the sewage effluent. Trade wastes at times need precipitation before admission to streams or sewers. The mixed liquids from a brewery are capable of much pollution of streams; they soon become acid, due mainly to the formation of lactic acid. The best method of treatment of brewery waste is chemical precipitation in the tanks, using a heavy dose of lime followed by land treatment or the use of deep percolating filters, triple contact usually being required. For tannery waste liquid and refuse from fellmongers' yards much the same treatment is requisite. In all these instances the rate of filtration must be low owing to the strength of the liquid. In dairying, polluting liquids are derived from washings from the various machines used, separators, churns, etc.; such refuse gives an objectionable appearance to small streams, and in hot weather may give rise to smell. Preliminary passage through a bank of peat fibre followed by land treatment or precipitation with sulphate of iron and lime in tanks with subsequent treatment upon deep percolating filters produces a satisfactory effluent.

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[1] See also "Trade Wastes" (1902), W. Naylor, and "Trade Waste Waters" (1913), Wilson and Calvert.

CHAPTER VI

DWELLINGS, SCHOOLS, AND HOSPITALS

THE conditions which influence the healthiness of the habitation are—(*a*) Those of its site and surroundings, with which may be included such arrangements of streets and neighbouring houses as affect the lighting and ventilation of the dwelling. (*b*) The structural details of the habitation itself, including among these not only questions of stability and of dryness of foundations, walls, and roofs, but also means of sewerage, refuse disposal, and water supply, and those points of construction which have concern with the prevention of fire. The provision of adequate means of escape for the occupants, in the event of fire occurring, is a point, too, which needs consideration in connection with building, especially in the conversion of large houses into flats.

SITE AND SURROUNDINGS

Sites—The subject of soil in relation to houses has been already referred to. In the country, especially, it is important that attention should be directed to drainage of the subsoil of the site, and a situation on rising ground and in the neighbourhood of trees, but not unduly obstructed by them, is to be preferred, as presenting especially favourable conditions in this respect. Other things being equal, it is best to have a south-east aspect for the front rooms, as in that case the maximum effect of sunlight on the front and back of the house is secured.

The character of the soil underlying the house needs to be particularly attended to; the model by-law of the Local Government Board prohibits the erection of a new building "upon any site which shall have been filled up with any material impregnated with any animal or vegetable matter, or upon which any such matter may have been deposited, unless and until such matter shall have been properly removed, by excavation or otherwise, from such site."[1] Land which has been recently used for the deposit of such material is unfit for building purposes, and effluvia, which can sometimes be appreciated by the sense of smell, are given off from such sites for a considerable period. At the end of three years or more, depending upon the depth and character of the deposit, very little risk of effluvia or subsidence exists provided the site of dwellings erected thereon is properly asphalted or covered with a layer of good cement concrete; at least 6 inches thick or 4 inches thick if properly floated as required by the model by-law. This precaution also prevents the passage of moisture and ground air, from the soil beneath, into the interior of the dwelling. In old houses joists and even floorboards often rest directly on the ground, making the floor damp and cold. When these conditions exist the wood will be specially liable to be affected with "dry rot," and the effluvia given off by the decaying wood, together with emanations from the soil beneath the house, will, of course, be apt to be drawn up into the dwelling.

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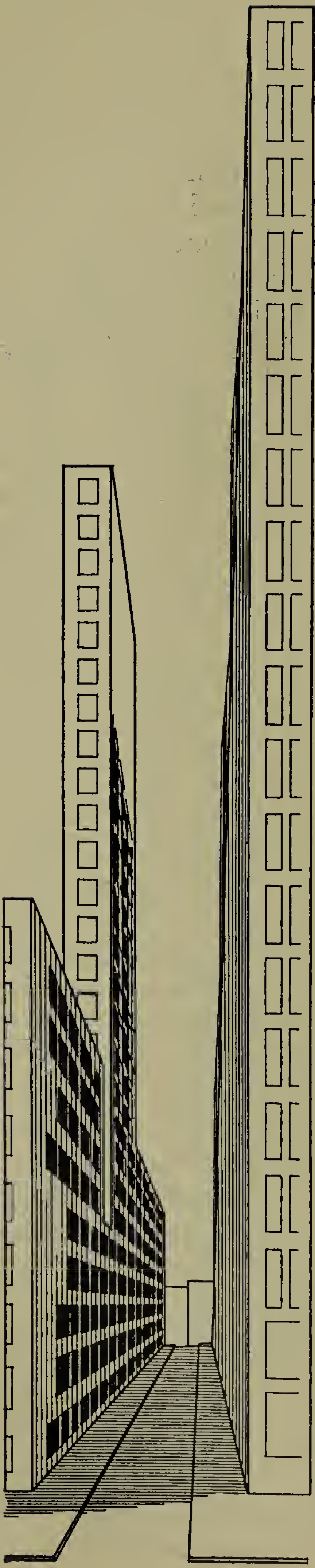
[1] Sec. 25 of the Public Health Acts Amendment Act, 1890, also deals with this matter.

Where the rooms in the lowest storey have boarded floors, the Model By-laws require that there shall be provided, between the underside of the floor joists and the upper surface of the asphalt or concrete, a clear space of 3 inches at the least, in every part; this space should be thoroughly ventilated by air bricks, or in some other effectual manner. In the by-laws of some local authorities covering with concrete is not insisted upon, provided the site is dry and the subsoil unpolluted. In such cases the model by-law of the Local Government Board prescribes that the ventilating space beneath the floor boards shall be at least 9 inches in depth; this involves fully two or more additional courses of bricks in the walls of the building, and thus very little saving is effected by the omission of the concrete.

Open Space about Buildings—In towns more particularly, the question of the amount of open space provided in front and at the rear of dwellings is apt to assume importance, inasmuch as, where building land is especially valuable, there is a natural tendency to cover the ground to the greatest extent permitted, and thus to interfere with the proper lighting and ventilation of houses. The desirability of adequately lighting inhabited rooms has been long recognised and modern knowledge concerning the effects of direct sunshine in improving the health of the individual and in destroying pathogenic organisms indicates that no room should be without direct sunlight during some part of the day. It is also important that there should be no dark corners, staircases or lobbies, as dust is apt to be unnoticed and to accumulate where it is not seen. It is also very important that completely circumscribed "shafts" and "wells" which would permit of the collection of stagnant columns of air, and such arrangement of tenements as would interfere with the proper renewal and interchange of the air of the rooms, should be avoided.

In the past but little attention was paid to such questions; it was common to build lofty houses on both sides of narrow streets



and to form culs-de-sac and dead-ends which prevented air movement, and led to more or less stagnation of the air in front of the houses. Again, it was a frequent practice to cause a court to be entered by a narrow passage-way overarched by a portion of a house fronting upon a main street. Such courts were themselves, in many instances, far too narrow, and often ended blindly, so that the air contained in them was practically stagnant. In towns, where land was especially valuable, but little space was left at the rear of buildings, and workshops or cottages have been in numerous instances erected upon the ground originally intended to be the backyard of a house; in many cases such back cottages not only possessed no means of through ventilation, but they were dependent for their air-supply upon the well of stagnant atmosphere situated between them and the front house, and by their presence they materially interfered with the ventilation and lighting of the rows of houses between which they were situated.

Other errors include right-angled projections for kitchens, sculleries and sliprooms in the rear of houses; high boundary walls to small back-yards; the proximity of the houses in adjoining streets all of which tend to render the air dead and stagnant. In many small squares and in very narrow streets the free movement of air is much impeded.

To secure sufficient space in front of buildings the Model By-laws lay down the width of streets desirable. They require (*a*) in the case of new streets intended for use as carriage-roads a minimum width of 36 feet; (*b*) for streets of a length not exceeding 100 feet in length and not in-

FIG. 64.—Buildings showing need for artificial light in offices. The black windows indicate where artificial light was being used near the windows at noon on a sunny summer day.

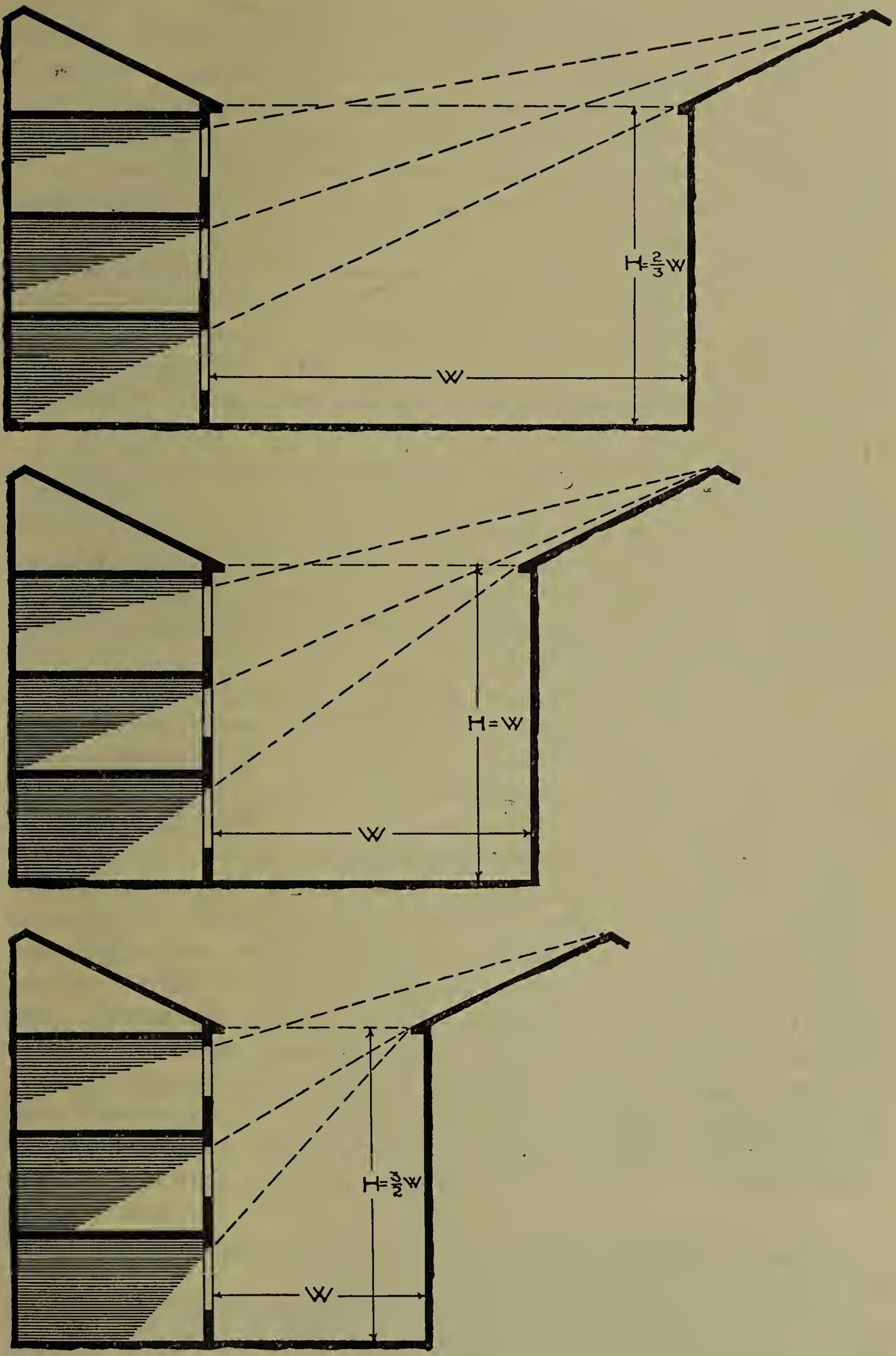


FIG. 65.—Sections showing the relation of width of street and height of buildings to the lighting of dwellings.
W. = Width of street.
H. = Height of building.

tended for use as carriage roads a minimum width of 24 feet; (*c*) for streets not intended to form the principal approach to houses [for removal of refuse] a minimum width of 10 feet. As regards the division of this space between footpath and carriage-way, 6 feet on each side are to be reserved for footpath. If the traffic does not call for such a wide carriage-way this can be reduced to 20 feet, leaving a strip which can be laid out in grass. Full advantage of this provision is taken in Liverpool.

The Model By-laws require every *domestic* building to have in front of it an open space extending at least 24 feet from the front of the house. The open space shall be free from any erection thereon above the level of the ground except any portico, porch, step, or other like projection from such building, or any gate, fence, or wall not exceeding 7 feet in height.

As regards a new house in a narrow street laid out before the confirmation of these by-laws, in order not to throw an undue burden upon the first person who reconstructs on one side it is required that if the open space provided throughout the whole line of frontage of each new building shall extend to a distance equal at least to the width of such street together with only one-half of the difference between such width and 24 feet.

As regards *space at the rear*, the Model By-laws provide that at least 150 superficial feet shall be kept free from any erection above the level of the ground, with the exception of a water-closet, earth-closet, privy, or ashpit. This space must extend the whole width of the building and at no point must it be less than 15 feet across to the boundary of the premises opposite.

Greater depths of open space are required for higher buildings [1] as follows:—height, 25 feet to 35 feet, depth, 20 feet; height over 35 feet, depth 25 feet. (Height is measured as the vertical distance from the ground in the open space to the level of half the vertical height of the roof or to the top of the parapet, whichever is the higher.) These requirements do not secure much space at the rear of houses, and in country districts a much larger amount of back yard, or garden ground, is usually provided. In large towns even the limitations referred to above are not always insisted upon.[2]

In London, in the Act of 1894, the principle that the amount of open space at the rear shall be proportionate to the height of the building is accepted, the height being limited by the requirement that it shall not exceed twice the distance from the rear of the building to the boundary of the open space provided. In other words, an imaginary horizontal line is first drawn at the level of the pavement, running at right angles to the centre of the front of the building, and is prolonged to the boundary of the open space at the rear of the building, and then, at the point where this line intersects the rear boundary, an imaginary diagonal line is drawn, in the same vertical plane as the horizontal line, and making with it an angle of 63½° ; the diagonal line, thus defined, controls the height of the building, no part of which, except chimneys, dormers, gables, turrets, or other architectural ornaments, must extend above this line. While this is the general principle held in view, certain exceptions are made ; moreover, the special circumstances of basement rooms below pavement level have to be considered. Thus, as regards habitable basements, the Act requires that all domestic buildings possessing them, which are erected after 1894, shall have a space of 100 square feet, free from any erection above the level of the pavement, provided at the rear, for the purpose of giving light and air to the basements. The detailed application of the general principle mentioned, and the exceptions admitted, remain to be referred to.

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[1] Several exceptions are made to this requirement; they are set out in the Model By-laws to which reference should be made.

[2] The requirements as to open space can now be approached from another angle. The Housing (Financial Provisions) Act, 1924 provides that the rate of density of the houses will not, except with the consent of the Minister, exceed eight per acre in an agricultural parish and twelve per acre elsewhere. To limit the number of houses to twelve per acre seems too stringent for most urban areas.

If a domestic building be erected, abutting upon a *new* street, it must have, at its rear, an open space of at least 150 square feet extending throughout its entire width, and at least 10 feet across in every part; but where there is a basement storey lighted and ventilated by the 100 square feet space already mentioned, or where there is no basement storey and the ground storey is not intended to be inhabited (as, for example, when it is used for business purposes), the open space of 150 square feet may be provided above the level of the ceiling of the ground storey, or a level of 16 feet above the adjoining pavement. The height of the building is controlled by the 63½° angle, as already described. Special sub-sections deal with the particular case of a building at a corner abutting upon two streets, or abutting upon one side on a street and on another side upon an open space not less than 40 feet wide, and permanently secured. In these and other exceptional cases the Council must be satisfied that due access of light and air is not interfered with.

As regards domestic buildings abutting upon *old* streets, a modification is made, the horizontal line being directed to be drawn not at pavement level, but 16 feet above this, and the 63½° angle is then applied as before. Moreover, the 150 square feet of open space, 10 feet across at every part, may be provided above the level of the ceiling of the ground storey, or 16 feet above the level of the adjoining pavement. An important exception is made, however, in the case of houses adapted to be inhabited by persons of the working class, as in such houses the open space must be provided from pavement level upwards.

Again, if domestic buildings (other than dwellings inhabited or adapted to be inhabited by persons of the working class) are *erected on old sites* abutting upon a street, the original conditions can be again reproduced, but no more ground must be occupied by the new buildings than was occupied by those previously existing. In other words, the conditions must not be made worse than they originally were. It will be obvious that in such a state of the law it is possible to newly erect, upon old foundations, buildings which will be very inadequately provided with rear space.

A very important section of the Act is that which relates to the provision of open space about dwelling-houses, adapted to be inhabited by persons of the working-class, and which do not abut upon a street. In the case of such dwellings plans must be submitted to the London County Council, and the Council may refuse its sanction to such plans if the open space, or spaces, provided are found not to be equivalent to the open space, or open spaces, which would have to be provided if the dwelling-house were erected abutting on a street or way formed or laid out before the commencement of the Act. This provision gives a most important, though somewhat limited, power of control over the erection of working-class dwellings upon "back land."

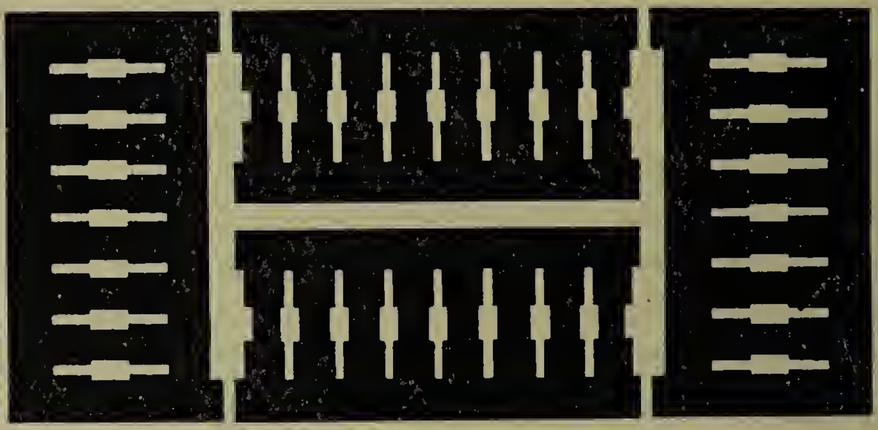

Fig. 66.—Plan of 4 blocks of 4 or 6 storey tenement buildings showing quite inadequate internal lighting and air supply courts and shafts.

Another important section of the London Building Act of 1894 is that concerned with the lighting and ventilation of rooms opening into the *internal courts* or shafts, which are so common in block buildings, and in dwellings constructed to be let in flats. Where such a court is enclosed on every side, and where its depth measured down to the ceiling of the ground storey, exceeds its length or breadth, adequate provision for its ventilation, by means of a communication at its lower part with the outer air, must be made and maintained; moreover, a habitable room which has no window, other than one opening into such a court, must comply with the condition (subject to slight modification in exceptional circumstances) that the width of the court, from the window to the opposite wall, shall be equal to at least half the distance from the sill of such window to the eaves or parapet of the opposite wall.

HABITABLE ROOMS

The Model By-laws require that habitable rooms shall be in every part thereof 8 feet at least in height from the floor to the ceiling except that if such room be wholly or partly in the roof of such building it shall be 8 feet at least over not less than two-thirds of the area of the floor and not less than 5 feet in height in any part thereof.

Windows—In each room there shall be one window at least opening directly into the external air. The total window area clear of sash frames shall be equal at the least to *one-tenth* of the floor area. The window or windows shall be so constructed that a total area equal at the least to one-twentieth of the floor area may be opened and so that the opening may extend in every case to the top of the window.

Every habitable room without a fireplace and flue shall be provided with special means of ventilation by an aperture or air shaft of an unobstructed sectional area of 100 square inches at the least.

Size of Rooms.[1]—In the description of houses which will qualify for assistance under the provisions of the Housing, etc., Act, 1923, the following is considered a desirable standard (circulars 388*a* and 520).

Living room	about 180	sq. feet.
First bedroom	„ 150	„
Second bedroom	„ 100	„
Third bedroom	not less than 65	sq. feet.

DENSITY OF POPULATION

Newsholme's investigation [1] concerning the vital statistics of the occupants of Peabody Buildings showed that the death-rate in these buildings was about two per thousand lower than that of London, for the twelve years ending with the year 1885. The infantile mortality was much lower in the Peabody Buildings than in London as a whole. The death-rate from phthisis and other tuberculous diseases was slightly higher, and diseases of a specially infectious character, and particularly whooping cough and measles, were found to be more fatal than in London generally.

The occupiers of the dwellings referred to are, it must be borne in mind, to a large extent specially selected, and care requires to be exercised in drawing conclusions with regard to the mortality experienced by them. While this is the case it must be admitted that the results of housing large numbers of persons upon a limited area, provided due regard is paid to the question of arrangement of the buildings and of their sanitary condition, are not so serious as the investigations concerning density of population, made by Farr half a century ago, led him to assume that they would be. On the other hand, there is a certain amount of evidence pointing to the conclusion that diseases due to direct infection tend to show increase when persons are housed in large numbers in blocks of buildings, even when care is devoted to designing the arrangement of the rooms in such blocks. Newsholme considers that the "essential element in testing the true density of population is a statement of the number of persons living in each occupied room." This test, he thinks, combined with a determination of the population on a given area, would give the most trustworthy estimate of density, and "the two together would determine the probabilities of the incidence of the diseases connected with overcrowding, and of the rapid spread of infectious diseases."

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[1] See "Journal of the Royal Statistical Society," 1891.

It has long been recognised that the mortality rate is greater in the town than in the country. Over fifty years ago Farr[1] found that mortality (m) varied approximately as the tenth part of the density (D) of the population $\left[m^1 = m\left(\frac{D^1}{D}\right)^{0·11998}\right]$ and, in spite of the greater sanitary improvements carried out in towns as compared with the country since that time, Brownlee shows that practically the same relation exists at present. The young child suffers even more from town life than the adult; he is necessarily more indoors and has less exercise in the open air, also he is less exposed to the sun's rays which are diminished by the interposition of a smoke-laden atmosphere. Each of these conditions causes lack of tone and predisposes to rickets.

Infantile mortality is regarded as a delicate test of sanitary conditions. The infantile mortality in urban areas is greater than in rural areas for example. In England and Wales in the year 1921 the infantile mortality for urban areas was 86·00, for rural areas 69·55.

Extreme density of population goes hand in hand with poverty with its accompaniments—carelessness as regards infection and the early signs of disease, diminished resistance to infection and illness, inability to carry out the treatment required and consequent lessened chance of survival when attacked by severe sickness.

The question of the need for *open spaces* is one which, especially in recent years, has received some amount of attention in large towns.

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[1] Supplement to 35th Annual Report of the Registrar-General.

The formation of squares and gardens, the provision of cross streets at frequent intervals, and the desirability of so dealing with the land at the corners of streets as not to interfere unduly with circulation of air, are matters which have received some consideration in connection with building schemes on large estates. Instances of this are afforded, for example, in the Grosvenor and Bedford estates in London. Again, the need for laying out public parks has not been altogether lost sight of, and the Metropolitan Open Spaces Acts of 1877 and 1881 provided for the acquirement of disused burial-grounds and their maintenance as open spaces. (For the extension of these powers to places outside London, see p. 738.) It has been suggested that in town planning eight acres are needed for every thousand of the population: five for games, two for allotments and one for parks.

The evils of close aggregation of dwellings may be especially illustrated by consideration of the question of *back-to-back houses.* Tatham collected statistics relating to the registration districts in Salford for the five years 1879–83, which showed in a striking way how mortality increases in correspondence with the extent to which back-to-back house construction prevails. Thus, in the Regent Road registration district, a portion of the area containing no back-to-back houses showed a mortality of 26·1 per thousand; in a portion of the area with 18 per cent. of back-to-back houses, the mortality was 29·1 per thousand; and in a third portion with 50 per cent. of back-to-back houses, a mortality of 37·3 per thousand was recorded. Similarly, in the Greengate registration district, three portions (enumeration districts), with 0, 23, and 56 per cent. respectively of back-to-back houses, showed death-rates of 27·5, 29·2, and 30·5 per thousand.

A joint report, prepared by Barry and Gordon Smith, dealing with the subject of back-to-back houses, was published by the Local Government Board in 1888; one of the conclusions arrived at, as a result of this inquiry, was to the effect that the want of through ventilation, *per se*, had probably had an unfavourable influence upon health, and had given rise to an increased mortality from pulmonary disease including tuberculosis, and diarrhœa. Further, it was found that "the difference in the cost of construction of a through house and of a back-to-back house respectively, each affording the same accommodation and built equally well, is very slight indeed, the advantage, such as it is, being with the back-to-back house." It was submitted, as the general outcome of the investigation, that the Board should refuse to sanction any by-laws which would permit the erection of back-to-back houses, and should discourage, by all the means at their command, the erection of such houses.

Further inquiries have since been made concerning the mortality statistics of back-to-back houses by Niven in Manchester, and by Evans in Bradford, and recent Building Acts and codes of by-laws contain, as a rule, provisions, the intention of which is, no doubt, to make the erection of such houses illegal. So far as cottage dwellings are concerned, the desired end is, as a rule, attained, but it does not appear that the possibility of reproducing objectionable types of construction of dwelling-rooms, in the case of block dwellings, is adequately guarded against.

J. F. J. Sykes has pointed out that " each accretion to the room, the dwelling, the house, and the block demands correspondingly amplified building restrictions, or, in the complications resulting from the heaping of Ossa on Pelion, the methods of construction prohibited in the simplest type, are reproduced in other and more aggravated forms in the larger and more complicated pile." He observes that in order to prevent the construction of what are practically back-to-back houses in blocks of dwellings, it is necessary that there should be a requirement " that in every dwelling consisting of two or more communicating rooms, at least one of the rooms shall possess a window opening on the opposite side of the building to that in which the window of the other room, or one of the other rooms, is situated."

In some sets of " flats," the block is not limited by being only two rooms deep, but is designed to admit of the construction, not merely of rooms lighted from its front and rear, but also of intermediately placed rooms ; such internal rooms are made to abut upon a central well, or are lighted by means of windows opening upon courts, which penetrate into the depth of the block, from its front or its rear aspects. These central wells are apt to contain more or less stagnant air, and the rooms opening into them, in the lower storeys of the block, are likely to be much darkened. Again the court which passes into the depth of the block from the front or rear of the building is often narrow, and thus much overshadowed, and rooms opening upon it are far less favourably placed, so far as ventilation is concerned, than if they abutted upon the front or rear walls of the building ; moreover, if they are on the lower storeys and near the dead end of the court, they are likely to be dark and gloomy. The conversion of ordinary houses into flats is apt to create insanitary structural conditions if not carefully supervised ; to mention one point, the bathrooms are often small and poorly ventilated and a source of danger to life if a geyser is used.

STRUCTURAL DETAILS

Under ordinary circumstances the external or party walls enclosing new buildings should be formed only of " good bricks, stone, or other hard and incombustible materials, properly bonded and solidly put together " with suitable mortar and cement. The " proper bonding " is usually effected by one of two methods—either, as in what is termed Flemish bond, each course contains " headers " (bricks laid transversely) and " stretchers " (bricks laid longitudinally) placed alternately, or, as in English bond, courses of " headers " alternate with courses of " stretchers." Walls so bonded must be at least the length of a brick in thickness (9 in. brickwork). When walls exceed 25 feet in height or 30 feet in length they are generally required to be of greater thickness, and codes of by-laws usually prescribe in detail the circumstances under which 13½ inches, 18 inches, or greater thicknesses of brickwork shall be used.

In some cases, in detached houses, half-timber walls are permitted, under appropriate restrictions, designed mainly with the object of securing stability and reducing to a minimum the risk of spread of fire. In houses with hollow walls the cavity must not exceed 2½ inches in width and the thickness of the inner and outer walls must not be less than 4½ inches.[1] The walls must be securely fastened together with ties of galvanised iron, of iron tarred and sanded or of glazed stoneware at distances apart not exceeding 3 feet horizontally and 18 inches vertically.

All woodwork such as the heads of door frames, window frames, lintels or similar structures inserted in hollow walls or walls composed of hollow blocks and extending across the cavity shall be covered throughout on the upper side thereof with a layer of sheet lead or other suitable material impervious to moisture in such a manner as effectually to protect such woodwork from any moisture which may enter the cavity.

In the construction of hollow walls lumps of mortar may fall into the hollow and remain touching both outer and inner walls, with the result that a bridge is formed which allows moisture to pass from the outer to the inner walls; these make damp patches on the inner walls. Great care should therefore be taken to have these removed as building proceeds.

Hollow walls (4½ inch outer and 9 inch internal walls) are equal in the retention of warmth and the exclusion of damp from driving rain to at least a 22½-inch solid wall. In the absence of hollow walls or sufficiently thick solid walls the exterior may be covered with trowelled Portland cement compo. The rough cast wall is generally preferred because it looks better, but in point of fact it is inferior to the smooth surfaced wall as it retains moisture, is colder and weathers more quickly.

The footings of walls should rest upon solid rock or upon a sufficient foundation of concrete. It is usual in building regulations to prescribe the width, height, and arrangement of the footings.

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[1] The Model By-laws also set out requirements as to hollow blocks.

Prevention of dampness. The walls should be provided with "a proper damp course of sheet lead, asphalt, or slates laid in cement, or of other not less durable material impervious to moisture." As a damp-proof course is of such essential importance care should be

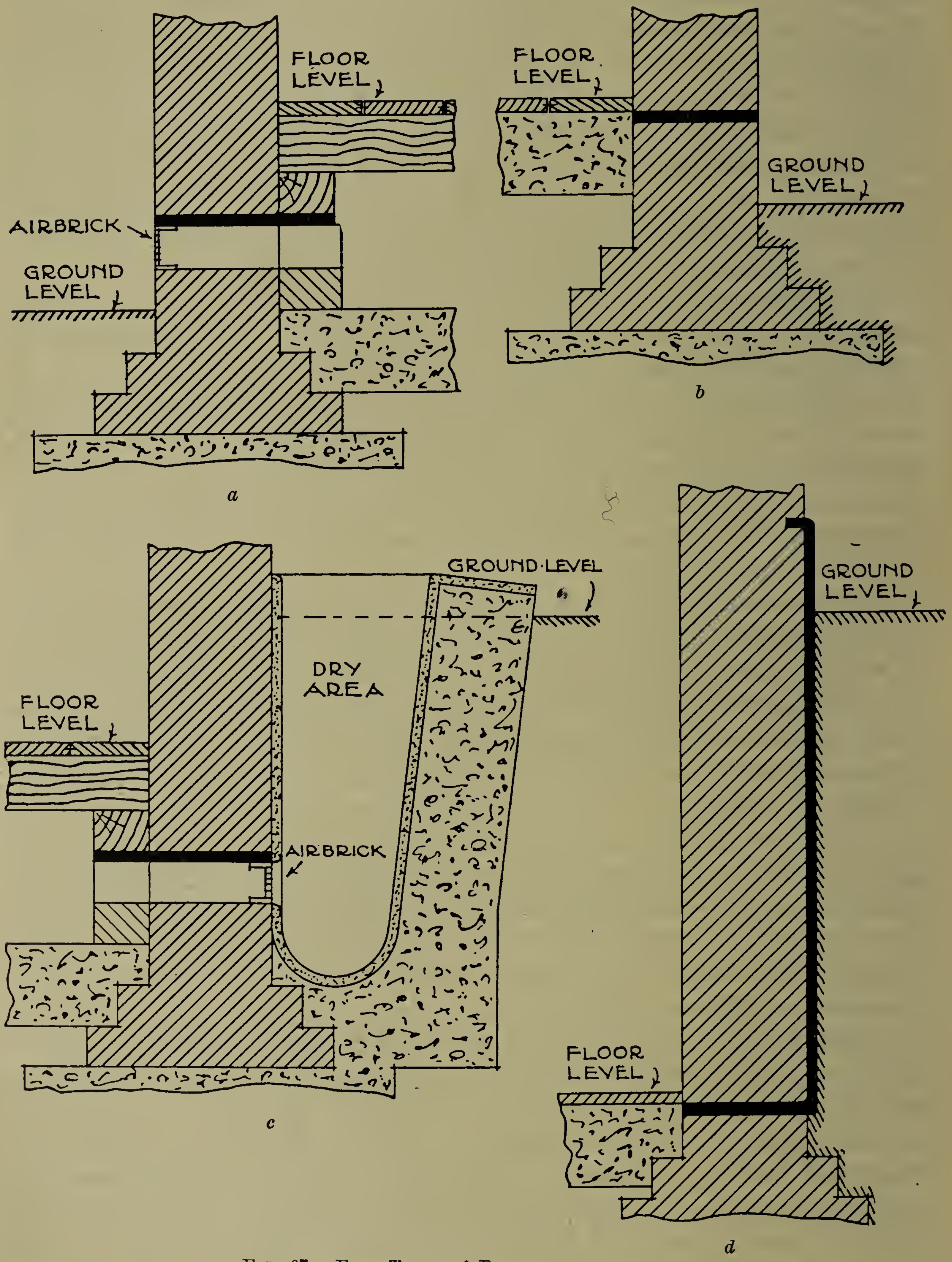

FIG. 67.—Four Types of Damp courses.
a. Damp course for hollow floor.
b. Damp course for solid floor.
c. Dry area with damp course for hollow floor.
d. Vertical asphalt damp course to prevent dampness from abutting soil—solid floor.

taken to prevent perishable substitutes taking the place of sheet lead or slates laid in cement. The damp-proof course should be placed beneath the level of the lowest timbers and if there is a solid floor not higher than the upper surface of the concrete, etc., forming the structure of the floor; it must also be not less than 6 inches above the surface of the adjoining ground.

The insertion of a damp course is necessary to prevent moisture being absorbed by the bricks. Such "ground dampness" ascending in an unprotected wall leads to rotting of woodwork and spoils the appearance of the wall; it favours development of mould and produces a musty and unwholesome condition of rooms.[1]

In old houses, the walls of which are unprovided with a damp course, it is a common thing to find basement and ground-floor rooms "match-boarded," with a view to concealing the unsightly appearances caused by damp walls. Where the match-lining does not extend to the ceiling, evidence of dampness can often be detected above the woodwork. Such covering up of walls, while it removes the cause of offence to the eye, does not, of course, prevent the damp brick-work causing pollution of the atmosphere of the room.

In many old houses the ground-floor rooms are below the level of the street or adjoining pavement; under such circumstances the walls of these ground-floor rooms are frequently found to be damp; this state of things is aggravated, more often than not, by the absence of a damp course.

In the case of basement rooms an area should, if possible, be formed to keep the ground away from the wall, or the outside of the wall should be covered with impervious material. Codes of by-laws often prescribe the adoption of a device as follows:—a hollow wall is constructed and two damp courses are provided, one at the base of the wall below the level of the floor-boards, the other above the ground level and at the top of the cavity of the hollow wall (6 inches above the ground).

Paving the ground adjoining walls is often productive of marked benefit in preventing dampness, especially in the case of old houses without damp-proof courses. Moreover, care requires to be taken that sink wastes, rain-water pipes, etc., do not discharge in such a way as to favour such a condition by splashing or otherwise; scullery waste-pipes are sometimes cut short, allowing the waste water to trickle down the wall on its way to the gulley. Also the gulley trap may be at a distance either from the waste-water or rain-water pipes, causing wetness of the yard surface.

Leaky gutters and down-pipes are common sources of dampness; these fittings should stand an inch or so away from the walls so that if they are stopped up or leak the walls will not necessarily be made damp. In exposed situations driving rain is apt to cause trouble, penetrating through decayed mortar or soft porous bricks. If the mortar alone is at fault repointing the brickwork suffices; if the bricks are at fault, the walls should be coated with cement or other impervious material: slates are sometimes used for this purpose, or even hollow walls.

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[1] The best palliative is to render the wall with a coating of waterproof cement.

Leakage through defective roofs is one of the most common sources of penetration of moisture into living-rooms. In old houses, after stormy weather, the ceilings of top-floor rooms often yield evidence that a slate or tile has been displaced or that the ridge tiles are defective and, in dilapidated and neglected houses, it is no uncommon thing to find ceilings stained and discoloured with the marks of many a storm. Chimneys and walls projecting above the level of the roof should be provided with lead flashings, flat pieces of lead placed below the slates or tiles and bent up so as to cover over the angle between the tile and the brick of the chimney. Chimneys and any such walls should be provided with damp courses immediately above the level of the roof. The coping of division walls should not be overlooked when searching for possible causes of damp. The roof should project well over the walls.

Roofs should not only be weather-tight, but should be so constructed as to protect the upper rooms from external heat and cold. Thatch is objectionable; it tends to undergo decomposition, harbours rats and mice, and is a source of danger in case of fire. Slates laid on boarding and felt are very generally used for roofing purposes; if the slates are merely laid upon laths the rooms are not sufficiently protected against heat and cold, and will be unduly hot in summer and cold in winter. Tiles afford better protection against extreme conditions of temperature, but do not so readily facilitate the escape of rain as slate does, hence the slope of the roof is usually made much steeper when tiles are employed.

In old cottages the staircase sometimes leads directly from the living-room into the bedroom, and in that case vitiated air from the living-room escapes into the bedroom, instead of fresh air being supplied, as it should be, from a well-ventilated passage or staircase. G. V. Poore has pointed out that in many old houses "the staircase oscillates between water-closet doors and bedroom doors, getting darker and darker as it ascends," and, as he says, it is often the case that "the internal channels of communication, instead of serving for the supply of fresh air, merely facilitate the exchange of foul air."

Certain precautions should be adopted to prevent the spread of fire. Party walls should be continued above the roof, forming parapets, as otherwise flames blown across the roof may split the slates, exposing the roof timbers, and the spread of fire from one building to another may be thus favoured. Moreover, roofs, gutters, and down-pipes should be made of incombustible materials. Again, building regulations generally control the making of openings in party walls, with a view to limiting risk of spread of fire, and they often prohibit the use of timber in party walls and deal with the mode of constructing chimneys and flues.

In block buildings it is usual to construct floors and staircases of fireproof materials, and solid floors are also to be preferred from the standpoint of health. In passages, stone and tiles are often used. Wood is warmer for living-rooms; oak and teak are fire-resisting but expensive. The ordinary deal floor tends to wear unevenly, but much can be done, as regards preventing the formation of crevices, by careful laying with properly grooved and tongued joints. Slagwool may be used with the object of deadening sound; ordinary "pugging" (sawdust, plasterer's rubbish, etc.), which is often employed, is objectionable; indeed, all possibility of collection of decomposable matter such as organic dust and débris beneath floor-boards and in crevices, should be carefully guarded against. In the case of lofty buildings it is especially necessary that attention should be paid to the question of providing alternative means of escape in case of fire, so that if the principal staircase become blocked by smoke there shall be no possibility of persons being caught, as it were, in a trap, and exposed to risk of being burnt to death. The London Building Act makes the adoption of special precautions compulsory in the case of public buildings (this expression includes *inter alia*, lodging-houses, blocks of dwellings, etc., in which more than 100 persons sleep).

UNFIT HOUSES

The houses in slums can often be described as damp, dilapidated and worn-out. In these houses are found many of the building faults mentioned above; in addition the plaster-work of walls and ceilings may be defective and broken which is not only unsightly but makes cleansing impossible. Accumulations of superimposed wall papers may be partially detached from the walls. The old and worn-out character of the property is most apparent in the woodwork. Externally, sagging of the roof may be apparent; internally the floor-boards may be worn and worm-eaten, presenting a surface difficult to keep clean. On stepping firmly on the floors they give markedly. The stair-treads also may have their nosings worn back over the risers. The framework of the windows is frequently worn out. The ceilings of old houses may bulge; also bricked scullery floors may show worn-out hollows and the coppers may be tumbling down.

Before representing individual houses [Part II of the Act of 1890], as unfit for human habitation the inspector should make a plan of the house showing the superficial area and height of the rooms, the size of the yard, the height of adjacent buildings and yard walls; the last emphasises the well-like character of many yards. Notes of the various defects should also be made in relation to each room. If it is possible to put the house again into habitable repair advice should be given to the owner as to how he can best meet the requirements of the local authority.

Artisans' Dwellings—Ample space should be provided both in front and at the rear of each block; the height of the building should be limited to three, or at most four storeys, unless the distance across the open space to the front and rear be unusually great; the length of each section should also be restricted so as to promote circulation of air. Blocks should not be connected at a right angle or an acute angle. The need of such arrangement of rooms as will favour through ventilation has already been insisted upon.

Staircases should be built against outer walls; the dark and inadequately ventilated "central" or "internal staircase" constitutes an especially objectionable feature in many old houses. Moreover, the staircase should be sufficiently wide; a width of 3 feet 6 inches has been proposed and adopted in some instances as the minimum permissible. There is great advantage in "open staircases" from the point of view of ventilation. Baths and washhouse accommodation are now often furnished in connection with block dwellings. Again, a good cupboard or larder, ventilating into the external air, should be provided in each tenement. Water-closets should be practically outside the dwelling, and should therefore, if possible, be placed so that they are entered through a disconnecting lobby furnished with means of cross-ventilation. Dust shoots, if provided, need special contrivance, by means of double doors opening and closing together, or by some other means, to prevent nuisance. If possible, their use should be avoided.

Block dwellings are frequently constructed with balconies running the whole length of the building on each floor. Under these circumstances rooms, more particularly those on the lower floors, are apt to be much darkened. There is advantage in not constructing rooms of too small dimensions. The smaller the room, the more difficult it is, other things being equal, to secure its being properly ventilated, and tenements consisting of small rooms are especially likely to be overcrowded. In the scheme for the provision of such dwellings the Ministry of Health recommend that dwellings should have through ventilation from front to back or from front to side, blocks of dwellings should not exceed 150 feet in length, outside balconies are deprecated as destroying privacy and obstructing light to the rooms below. The standard areas of rooms and the percentage of various roomed flats should be as follows :

Rooms excluding Kitchen-scullery.	Percentage of Number Provided.	Superficial Area in Feet.
4	70	180, 150, 100, 65
3	20	150, 150, 80
2	10	130, 120 or 250 together

Sykes, in his Milroy lectures on " The Influence of the Dwelling upon Health," enumerated certain other minimum requirements which included (1) That the common staircase is permanently ventilated at each floor level or by through ventilation so as to break the common air connection ; (2) that there is at least one draw-tap and sink with a constant supply of water for every twelve occupants or less on each floor ; (3) that there is at least one water-closet, properly and efficiently supplied with water, for every twelve occupants or less on each floor, disconnected aerially from any dwelling in the interior of the building ; (4) that on each floor a sufficient space, or open lobby, is provided, accessible to and for the use of each family on each floor, for the deposit of refuse, etc. ; (5) that accommodation for clothes washing is provided sufficient to enable each family to occupy the washhouse or appliances one day in each week.

In the case of existing buildings " adapted by alterations " to be occupied as separate dwellings, the standard must necessarily be a less satisfactory one than in new buildings. The points to which attention should be directed during inspection are :

(1) That the common staircase is amply and permanently ventilated into the open air. (2) That the dwellings are ventilated through, from one point to another. (3) That the water supply is in conformity with statute. (4) That a draw-tap and sink are provided on each floor for every twelve persons or less. (5) That the drainage is in conformity with statute. (6) That clothes-washing accommodation is provided for each family on at least one day a week. (7) That there is water-closet accommodation, for every twelve persons or less on each floor, properly disconnected, aerially, from the dwelling. (8) That there is an open lobby space, or balcony, on each floor, available as a place of deposit for the dust receptacle and offensive refuse.

In cases in which the ground-floor rooms of buildings are used for commercial purposes, the dwelling-rooms above are liable to be exposed to the influence of a much polluted atmosphere. The site on the ground storey is often entirely covered with buildings, and proper ventilation is rendered impossible; moreover, the ground-floor rooms are generally dark, and artificial light is therefore likely to be frequently resorted to; contamination from products of combustion then results. In the case of eating-houses and restaurants the smell of cooking is apt to pervade the upper rooms, and the extent to which contamination of the upper floors is often brought about is very clearly demonstrated by the condition of the atmosphere frequently observed in the bedrooms of old inns, and, indeed, it may be added, of ill-designed modern hotels.

Stable Dwellings—In towns it is a common practice to construct rooms, intended to be inhabited, over stables in "mews." Such rooms, in addition to being exposed to stable effluvia, often exhibit other serious defects (the "mews" may be a *cul de sac*, and the dwellings without through ventilation, etc.), and it is not surprising that the statistics of stable dwellings should show excess of mortality among the persons living under these unfavourable conditions. Sykes has investigated the question so far as the stable dwellings in St. Pancras are concerned. He found the death-rates from pulmonary disease and from zymotic disease (particularly diarrhœa and diphtheria) notably in excess, as was also the infant mortality. The London Building Act contains a special section dealing with the protection of habitable rooms which are situated over stables.

In large towns there are still many persons who live and sleep in *basement dwellings*. The extent to which the law controls the use of such dwellings is dealt with on page 669.

COMMON LODGING-HOUSES

The Act of 1875 contains no definition of the term "common lodging-house," but in the opinion of the law officers to the Crown as expressed in the Local Government Board Memorandum dated 20 · 11 · 1901, the term has reference to that class of lodging-house in which persons of the poorer class are received for short periods, and though strangers to one another (promiscuously brought together as distinguished from members of one family or household) are allowed to inhabit one common room. The term does not include hotels, inns, public-houses or lodgings let to the upper and middle classes. The period of letting is unimportant. Charitable institutions are included as common lodging-houses if the house is such, and is so carried on, as to be within the provisions of the Act.

A house, before being registered as a common lodging-house, must be "inspected and approved for the purpose by some officer of the local authority." The rules which should guide the inspecting officer in his examination are laid down in a Local Government Board Memorandum, which may be quoted as indicating the standard of fitness regarded as necessary in such cases :—

"The house should (1) possess the conditions of wholesomeness needed for dwelling-houses in general; and (2) it should further have arrangements fitting it for its special purpose of receiving a given number of lodgers.

"1. The house should be dry in its foundations and have proper drainage, guttering, and spouting, with properly laid and substantial paving to any area or yard abutting on to it. Its drains should have their connections properly made, and they should be trapped, where necessary, and adequately ventilated. Except the soil-pipe from a properly trapped water-closet, there should be no direct communication of the drains with the interior of the house. All waste pipes from sinks, basins, and cisterns should discharge in the open air over gullies outside the house. The soil-pipe should always be efficiently ventilated. The closets or privies, and the refuse receptacle of the house, should be in proper situations, of proper construction, and adapted to any scavenging arrangements that may be in force in the district. The house should have a water supply of good quality, and, if the water be stored in cisterns, they should be conveniently placed and of proper construction to prevent any fouling of water. The walls, roof, and floors of the house should be in good repair. Inside walls should not be papered. The rooms and staircases should possess the means of complete ventilation; windows being of adequate size, able to be opened to their full extent, or, if sash windows, both at top and bottom. Any room proposed for registration that has not a chimney should be furnished with a special ventilating opening or shaft, but a room not having a window to the outer air, even if it have special means of ventilation, can seldom be proper for registration.

"2. The numbers for which the house, and each sleeping-room, may be registered will depend partly upon the dimensions of the rooms and the facilities for ventilation, and partly upon the amount of accommodation of other kinds. In rooms of ordinary construction, to be used for sleeping, where there are the usual means of ventilation by windows and chimneys, about 300 cubic feet will be a proper standard of space to secure to each person; but in many rooms it will be right to appoint a larger space,[1] and this can only be determined on inspection of the particular room. The house should possess kitchen and day-room accommodation, apart from its bedrooms, and the sufficiency of this will have to be attended to. Rooms that are partially underground may not be improper for day-rooms, but should not be registered for use as bedrooms. The amount of water supply, closet or privy accommodation, and the provision of refuse receptacles should be proportionate to the numbers for which the house is to be registered. If the water is not supplied from works with constant service, a quantity should be secured for daily use on a scale, per registered inmate, of not less than ten gallons a day where there are water-closets, or five gallons a day where there are dry closets. For every twenty registered lodgers a separate closet or privy should be required. The washing accommodation should, wherever practicable, be in a special place, and not be in the bedrooms, and the basins for personal washing should be fixed and have water-taps and discharge pipes connected with them."

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[1] By-laws have been brought into operation in London for controlling seamen's lodging-houses which fix the standard at 400 cubic feet.

This Memorandum was issued in 1877, and since that time the type of building used for common lodging-house purposes has, in large towns, undergone material alteration. In numerous instances houses adapted for many hundreds of lodgers have been erected, and in these cases the conditions to be regulated are more comparable to those presented by block dwellings, which have been already mentioned, than to those of ordinary dwelling-houses. In the Memorandum issued in 1894, it is stated that it is desirable to limit the size of any building intended for occupation as a lodging-house, so that it may not accommodate more than some 200 lodgers. The desirability of providing a day-room with floor area affording some 15 square feet to each lodger is pointed out; sleeping-rooms, it is noted, should be of moderate size, holding not more than about twenty lodgers each; each bed, it is suggested, should have some 5 feet lineal across it, 40 square feet of floor area, and from 300 to 400 cubic feet of space. Water-closets in the proportion of one closet for every fifteen to twenty lodgers, and fixed lavatory basins in the proportion of one basin to every ten lodgers, are recommended. A properly contrived hot-closet for drying the wet clothes of lodgers is also stated to be a desideratum.

The lighting of rooms, and the need for securing adequate through ventilation, require to be particularly attended to in large houses. The practice of partitioning rooms off into cubicles, while it affords privacy for lodgers, is likely to be attended with serious interference with both lighting and ventilation. The "open dormitory" system possesses, therefore, great advantages over the cubicle system from a health point of view. Dormitories are sometimes heated by hot-water pipes, and special arrangements for the extraction of foul air, or the supply of fresh air, have, in some instances, been made.

In large buildings, the question of providing means of escape in case of fire assumes special importance. The standard of cleanliness, too, has been raised of late years, and in many modern lodging-houses baths are provided; the requirements of the inmates are thus not altogether limited, as in former days, to "basins for personal washing."

SCHOOLS

A school should be built on an open site well away from lofty buildings or any structure likely to cause stagnation of the air around the school premises.

Other essentials are facilities of access for the scholars (the school must be in as central a position as possible in the district it serves), freedom from noise and dust, absence of adjoining sources of nuisance such as smoking chimneys of works, premises of offensive trades, brickyards, etc.

Proximity to a public park where organised games may be played is an asset to a school. If the site has to abut upon a much-used roadway the building should either be set well back or have its class-rooms on the side away from the street so that noise and dust may not provide a reasonable excuse for shut windows. Exits on main roads should be safeguarded by barriers from the carriage-way.

As regards the area of the site a quarter of an acre should be provided for every 200 children irrespective of space for teachers' or caretakers' houses or special subjects centres. If the school is more than one storey the area can be proportionately reduced but not so as to reduce the playground space mentioned below.

The arrangement of a school building depends upon the number of children for whom provision is to be made, and on the amount of land available. As a rule each school is divided into separate departments for boys, girls, and infants; occasionally a department, "Junior Mixed," for boys and girls from seven to nine or ten years of age is provided.

The most desirable plan, when sufficient land is available at a reasonable cost, is that in which each department is provided with a separate building, all the rooms being on the ground floor. As a rule it is found necessary to place one department above another on two floors. Only under exceptional conditions, such as when the land for building purposes is very costly, should buildings of two storeys be erected.

The Board's Regulations recommend a south-easterly aspect for the class-rooms or an easterly aspect in the warmer parts of England. An open, airy playground, with a sunny aspect, must in all cases be provided.[1] All playgrounds should be nearly square, properly levelled, drained and enclosed; they should not be covered with cinders, large stones, gravel, or be laid down in grass. A sufficient space should be paved or concreted so as to provide a surface suitable for physical exercises, and it is convenient to have one part under cover so that physical exercises can be carried on out-of-doors in wet weather. Playgrounds should be used in mild weather for ordinary class work as well as for physical exercise and might with advantage be kept open during daylight for the children to play in.

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[1] The sizes of the playgrounds are laid down in the Building Regulations for Public Elementary Schools, 1914, those for Secondary Schools, 1914, and in the Combined Regulations for Special Schools.

For small schools of about 100 *scholars or less*, a schoolroom with at least one other class-room will be sufficient; it must be lighted from more than one side; both gable ends should be fully utilised for windows.

For schools or departments of an intermediate size the most convenient plan is that of class-rooms opening on to a corridor, which can be used for physical training, singing, etc.,

The corridor must be fully lighted and ventilated directly from outside, and must be from 8 to 12 feet wide. In order that a large room may be available, two or three of the rooms should be separated by a movable partition.

For large departments of about 350 *to* 500 *children* there are two main kinds of school; one with a central hall and the other in which each class-room has direct through ventilation.

The school with a central hall communicating directly with class-rooms on all four sides has been replaced, to a large extent, by a modified type, consisting of a lateral hall with class-rooms on three sides, the fourth side being the outer wall of the building. Generally to obtain adequate ventilation in schools of this kind mechanical means must be employed.

The second kind of school has, as its essential feature, direct communication of the class-rooms on opposite sides with the external air; it therefore allows of cross-ventilation by natural means.

The Staffordshire type of school, as advocated by G. Reid, consists of a series of class-rooms with fixed hopper windows on opposite sides, opening directly on to the outer air. The class-rooms are connected by means of verandahs; each department—boys, girls, and infants—occupies a separate building. One semi-detached hall serves for all three departments.

If economy of space is essential, buildings of two floors can be erected on the same plan.

Another modification of the through ventilation type is that in which the class-rooms are side by side and are connected by a dwarf corridor; windows with hoppers are provided on both sides of the corridor, above which another hopper window places the class-room in direct connection with the external air; additional rooms can be placed if necessary at right angles at either or both ends; a detached central hall is necessary.

An elaboration of this plan produces a school built in the form of a square with an open corridor on the inner side; the hall is placed in the centre of the square with the latrines on either side. An example of this is Ripley Council School, Derbyshire (*see* Fig. 68).

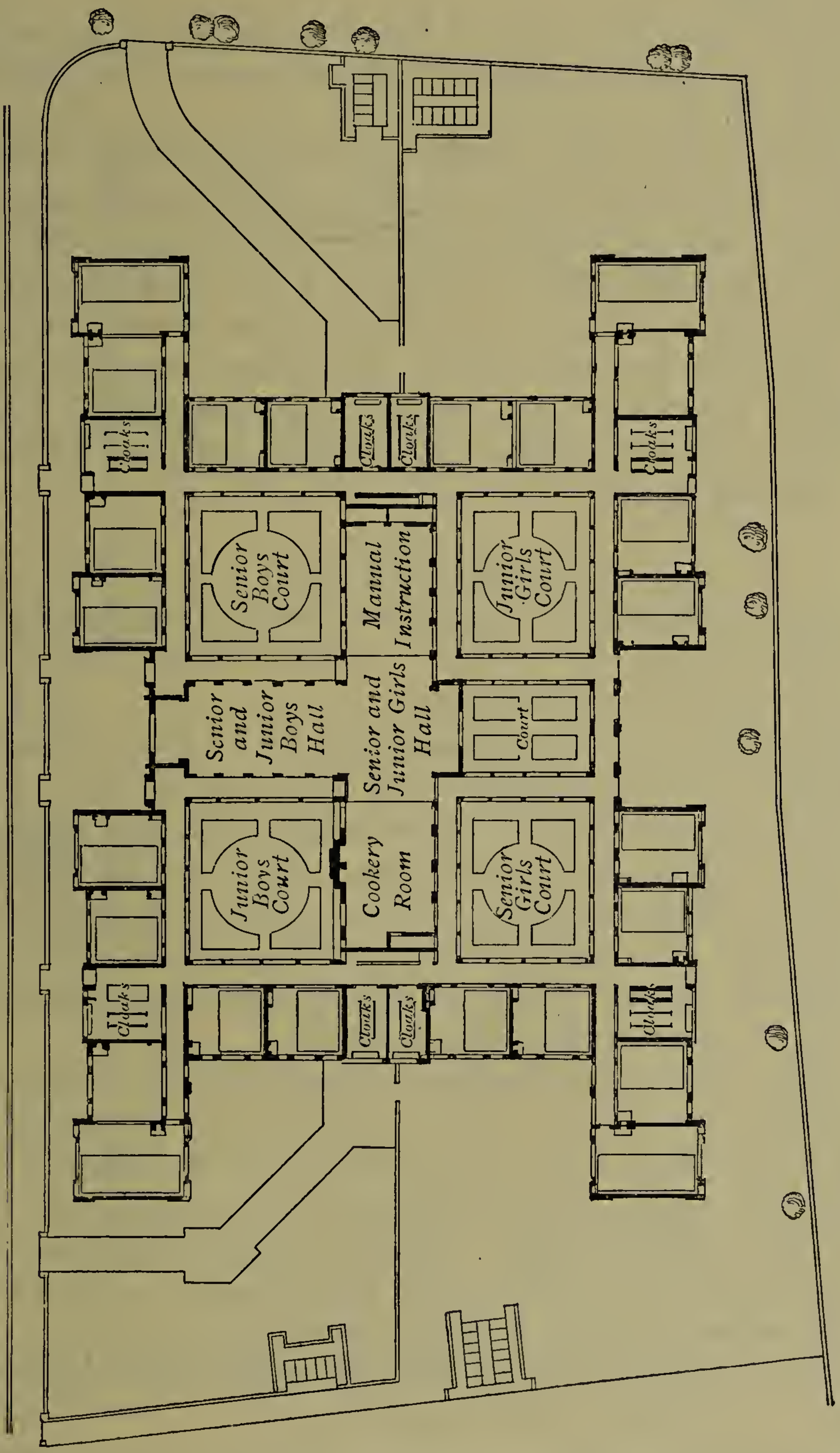

FIG. 68.—Plan of Elementary School at Ripley, Derbyshire Education Committee (G. H. Widdows, F.R.I.B.A., Architect).

This school accommodates 1,200 children and consists of four departments, the children being divided as they enter school into juniors and seniors and sexes: in the junior school the children are taught from the date of entrance up to the age of 9 years; in the senior school, from 9 years of age to the time of leaving. There are two halls with cookery and manual rooms; all four rooms can be thrown into one large hall for public meetings, etc.

As regards lighting, the proportion of glass to floor area is not less than 1 to 5; the whole of the lighting is received from the vertical faces of the walls.

The ventilation is by means of hoppers and swing lights on both sides of each room. The area of hopper opening on each side is approximately 10 square inches per child.

The heating is by means of low-pressure hot water on the overhead system; the water as it leaves the boiler is taken immediately up to the roof and then falls to the different rooms. The heating surface per 1,000 cubic feet of content is not less than 30 square feet. Rooms with baths are set apart for medical inspection, and dark rooms are provided for eye testing. The usual teachers' rooms are provided above the cloak-room, two to each department. The courtyards are laid out with grass and shrubs, and the whole of the verandahs are left open.

NEW BUILDINGS

The Board of Education require for new schools (*see* Circ. 1334, 28/6/24) a floor space of—

9 square feet for "Infants";
10 square feet for older children up to 11 years of age;
12 square feet for children over 11 years of age;

also that no class-room should be planned for more than fifty children with a maximum floor space of 500 square feet, and for children over 11 years of age that a majority of the class-rooms should not be planned for more than forty places. The minimum floor space in a class-room even in cases in which the classes are necessarily small must not be less than 400 square feet.

These rules refer only to new buildings. In rearrangements of existing buildings the Board will be glad, where it proves possible to adopt the new basis of 12 square feet for older children, but they will not on that account alone refuse to secure the best practical adaptation of existing buildings. Earlier Codes laid down as limits in neighbourhoods where there was a deficiency of school accommodation 80 cubic feet and 8 square feet.

Article 19 of the Elementary Education Provisional Code, 1922, states that

> "the average number of children in attendance must not exceed the recognised accommodation and no room may be habitually used for a larger number of children than that for which it is passed by the Board. The recognised accommodation of a school or department may from time to time be revised by the Board."

Consolidated Regulations relating to Special Services (Grant

Regulations) No. 19, require for blind, deaf, defective and epileptic children separate schools except structurally separated for each type, the physically defective being on the ground floor. The building must be planned on open-air lines. Each class-room must contain

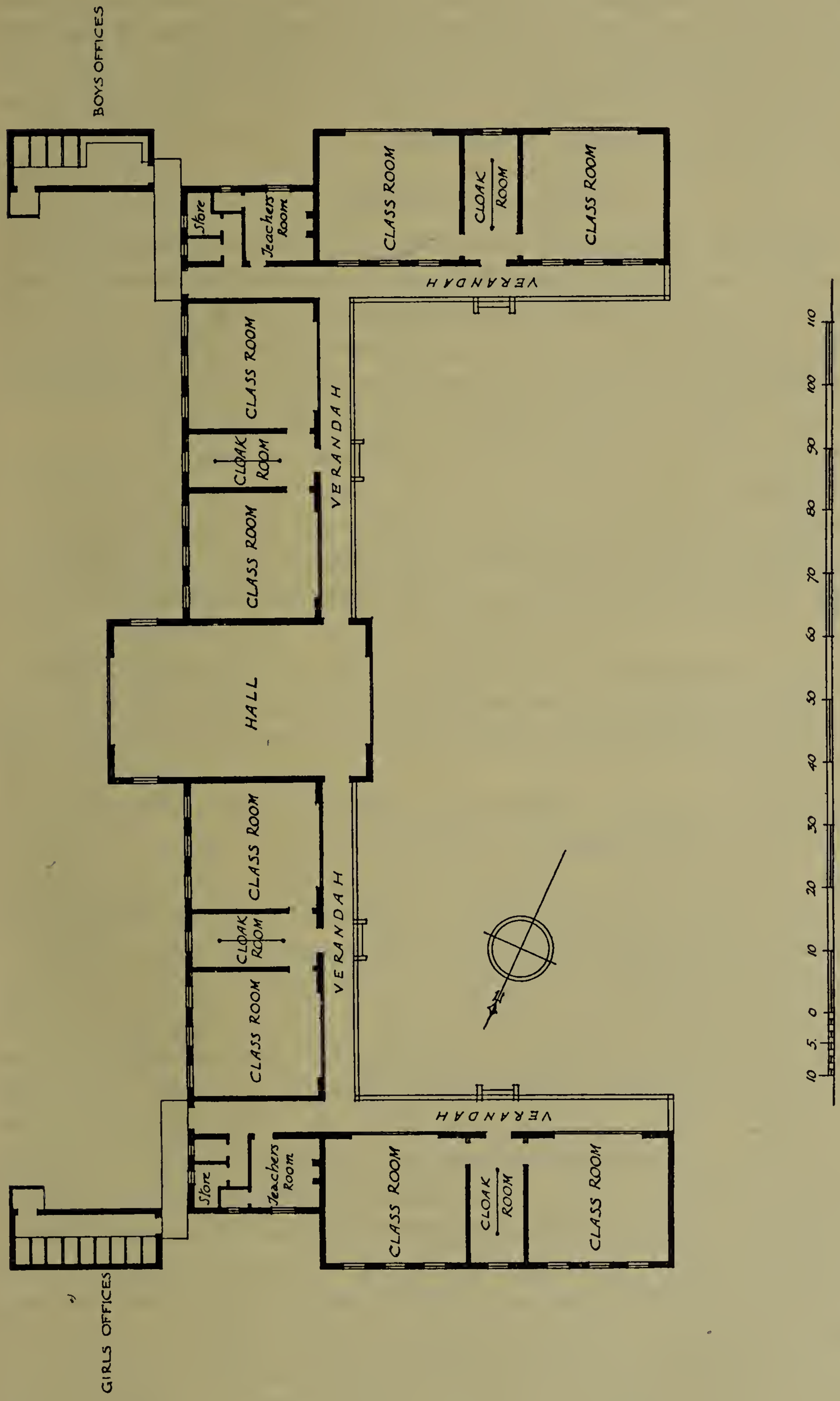

FIG. 69.—Plan of proposed public Elementary School at Moulscombe, Brighton (G. M. Simpson, F.R.I.B.A., Architect). The class-rooms are lighted from both sides; on one side are very large folding windows which when open practically make the class-rooms open-air rooms. Communication between the rooms is by an open verandah with glass roof.

not less than 15 square feet of floor space per child and in the case of cripples, some of whom require couches, at least 18 square feet. No class-room should contain less than 200 square feet of floor space.

The more frequent occurrence of infectious disease among younger children is a strong argument for providing a larger floor space for infants' departments although probably a more potent cause of spread is the group teaching of infants.

SEATS AND DESKS

The Board of Education insist on a satisfactory arrangement of the desks in any new school building. On this in part depends the number of scholars that can be accommodated.

In the ordinary long desk an allowance of 18 inches for each child is sufficient (for infants 16 inches). A gangway of 18 inches between the walls and each group of desks is necessary.

Space must be provided between each row of long desks for the teacher to pass.

An ordinary class-room allows of five rows of long desks, a room 22 feet wide four rows, a room 18 feet wide three rows. In new schools the Board of Education will only permit the provision of single or dual desks.

The usual length of a dual desk is 3 feet 4 inches (for infants 3 feet). In an ordinary class-room six rows of dual desks can be placed. A room 22 feet wide allows of five rows, a room of 18 feet wide four rows.

Gangways of 1 foot 4 inches must be provided at the sides of each dual desk. The teacher should be able to pass behind the back row.

The slope of the writing surface of the desk should be 7½°–8°; the tops should be adjustable so that for woodwork, etc., a flat surface should be available.

Back-rests should be provided for each child; the seats should have two cross back rests, one adjoining the seat of the chair to support the sacrum, one higher up to give support just under the shoulder blades. The advantage of the former rest can readily be tested by anyone by sitting well back in a chair when, if the sacrum is supported, the erect position can be more easily maintained. The higher back piece is to rest the listener and should be inclined backward. The feet should rest flat on the floor and the thighs flat on the seat parallel to the floor so that the vertical measurement from the sole of the foot to the lower surface of the thigh is equal to the height of the surface of the seat above the floor. The width of the seat with the child sitting well back should leave the lower quarter or even third of the thigh free from pressure of the front edge, otherwise pressure on the popliteal artery may cause numbness and cold feet. The edge of the desk should be either vertically above the seat edge (the zero distance) or 1 inch overhanging the seat edge (the minus distance). If the desk edge is separated from the seat edge (the positive distance) the pupil is enabled to stand behind his desk but a large positive distance leads to bending over the desk when writing.

The height of the edge of the desk should be just level with the tip of the xiphisternum. It is impossible to judge of the relative heights of seat and desk from the heights of the children as the relative lengths of body and limbs vary; the ideal is that single desks with adjustable seats should be provided and the seat adjusted for the child who will occupy it for most part of the time.

The babies' room of an infant school should be provided with small wooden chairs with backs and square tables of a suitable height.

THE CLASS-ROOM

It should not be necessary to pass through one class-room to get to another or to the playground.

The class-rooms should accommodate not more than 50 nor less than 24 children. At Bradford, in the newer schools, the maximum accommodation of a class-room is 40.

The Regulations specify that no class-room or "main-room" must accommodate such a number as to require two adult teachers. The planning must allow every room to be cleared easily without disturbing any other room.

The *walls* of a schoolroom should consist of impervious hard bricks set in cement, glazed bricks or enamelled tiles covering the ordinary bricks. Such a surface, being non-absorbent, can easily be kept clean.

Plaster absorbs impurities from the air and should not be used; plaster walls in existing schools should be painted in order to prevent such absorption.

The colour chosen should be one that does not tax the eye or absorb light to any appreciable extent. A light greenish grey fulfils both conditions.

A rounded insertion in the angle formed by the meeting of the walls and floors facilitates cleansing.

The ground *floors* of schools should be made of blocks of hard wood laid upon concrete, to which they adhere by a mixture of tar and asphalt. The interspaces between the blocks are filled with the same mixture. Such a floor is durable, clean, and noiseless.

Oiled pine flooring rendered noiseless by embedding in sand is also suitable.

If the room is warmed by hot-water pipes laid in the floor cement must be used.

The upper floors should be made of tongued and grooved planks of hard wood.

Some device is necessary to make the floor soundproof. This can be effected by placing a substance having the property of deadening sound in the space between the ceiling and the floor of the room above. Slag-felt, a preparation of slag-wool, is useful for this purpose. Nothing should be used which is of an organic nature or likely to give off a smell.

Terasso may be used for corridors and cloak-rooms. The 6-inch platform for the teacher mentioned in the Regulations should be avoided as it increases eye strain, particularly of children in the front rows, by keeping their line of vision still more raised above the horizontal. Stepped flooring (the galleries seen in old infants' departments) has been abandoned as the schoolroom cannot be used for exercises, also because of the difficulty of lighting.

Unless the top of the window be more than 12 feet from the floor no desk should be more than 20 feet from the window. The last vertical glass line of the window farthest from the teacher should be on a line with the back of the last row of desks.

The height of the class-room should not be less than 12 feet if the room has a flat ceiling and if ceiled at the collar beam the height should be 10 feet to the wall plate and 13 feet to the ceiling. These heights may be diminished by 1 foot if there are corresponding windows on opposite sides.

A form nearly square allows of the maximum number of desks properly arranged with regard to the windows.

Kerr works out the class-room measurements on the basis of vision and hearing. One-tenth of children have so low *visual acuity* that they cannot make out test letters of a couple of inches in height beyond 26 *feet distance. For that reason* blackboard work cannot be carried on at a greater distance *than* 26 *feet,* also greater distances limit the teacher's observation of the children's faces. Normal children can hear the forced whisper at 80 feet, but for ordinary class purposes and making allowance for many children with slight defects of hearing 25 *to* 26 *feet* is about the available limit for the teacher's voice.

The illumination will be sufficient across a room of width equal to twice the height of the top of the window above the desk level. With window top at 12·5 feet and desks 27 inches in height there will be sufficient light on desks up to 21 feet from the windows ; if a gangway be added the width limit is about 22 feet 5 inches. "*Limiting sizes for a class-room are therefore* 13 *feet in height,* 22 *feet in width and* 26 *feet in length.*"

CLOAK-ROOMS AND LAVATORIES

Places for each sex separate from schoolrooms, class-rooms, and passages must be provided to serve as cloak-rooms ; through ventilation must be established, and the place must be disconnected from the inner rooms lest the smells from dirty clothes, especially when damp, be carried into the school. Ample lighting must be provided. The cloak-rooms should have separate means of ingress and egress with gangways between hanging rails at least 4 feet wide.

The hat-pegs should be 12 inches apart, numbered and in two rows, the pegs of the bottom row below the middle of the interval between two pegs in the top row, thus providing 6 inches hanging space for each child. If space is available the hanging space should be increased. Each child should have its own peg so that the wrong cap, etc., cannot be taken by mistake and verminous conditions or ring-worm so spread.

The usual arrangement is for the hanging rails to be fixed to the walls of the room, but this plan does not permit of the free circulation of air and the rapid drying of clothes. The best arrangement is to use special metal cloak-room fittings, so placed as to allow a gangway between them and the walls. The cloak-rooms should be warmed so as to dry any wet clothes.

Supply of drinking water.—The use of a fountain with a mug attached to a chain should be deprecated—as many infections can be spread by the use of a common drinking-vessel. In new schools, jet fountains, of the Shanks pattern, have been installed. In these, a jet of drinking-water plays directly into the mouth. The number installed at present is one in each school department. The ideal would be one jet fountain at least for every 100 scholars.

Lavatory basins should be provided in the proportion of at least one to twenty scholars. One to ten scholars is desirable. More are required in girls' schools than boys' or infants'.

These basins should be fitted around the outer walls of a room.

Shower baths or spray baths may be provided to bath twelve to twenty children at a time. In this connection it is of the utmost importance that good soap should be provided as the cheap, yellow, resin-smelling soap often seen in schools causes patchy roughness of skins and sometimes cracks. Clean towels should be provided daily. The arrangements for the regulation of washing should be made by the Head Teacher who should give instructions that no child with red or discharging eyes, discharging ears or skin troubles should use the common towel. In the presence of an outbreak of " blight " the common towel must be taken away and small towels provided for individual children as required.

THE CLEANSING OF SCHOOLS

Dust and dirt are brought into school by the children on their clothes or boots, carried in by the air or produced in school from the wear and tear of floors, furniture, and various articles used in teaching, especially chalks.

It is further polluted by the addition of the liquid and solid particles derived from the human body. Chalk dust is not harmful as compared with dusts containing silica but dust of any kind clogs the mucous membranes and to some extent lessens their power of resistance. For that reason it is important that dust in schoolrooms should be lessened.

Children should be made to come to school with clean bodies and clean clothes; before entering they should be made to wipe their boots carefully on a scraper and mats.

The entering air can easily be filtered if mechanical ventilation is employed; in the case of natural ventilation all inlets allowing of cleansing should be cleaned at least once a week.

In order to facilitate the removal of dust, the number of cupboards, shelves, cornices, platforms, etc., should be reduced to a minimum; any ledge should slope downwards and forwards; the tops of cupboards should be made smooth, polished, and slightly sloped inwards towards the room; an iron rail is preferable to a picture moulding.

The use of a vacuum cleaner is the best method to adopt, but is not popular with caretakers as it involves the picking up by hand of the larger objects and pieces of paper. Next in cost and efficiency is the use of dust fixing oils as a floor dressing: this has the advantages of lessening the labour of cleansing a room and preventing the rising of dust once settled on the floor. Failing the use of either of these the floors should be swept daily after being liberally sprinkled with damp sawdust; the brooms used should also be damped frequently. As an alternative the floors may be lightly sprayed with a garden syringe fitted with a fine rose nozzle. Dry sweeping has a harmful effect on the health of the sweepers. All windows and doors should be widely opened during sweeping, and any disturbed dust that may settle on the furniture should be wiped with dusters damped with paraffin.

The use of linoleum as a floor covering facilitates cleansing.

The floors and *desks* should be scrubbed regularly with soap and water, and every desk cleaned thoroughly with paraffin oil during each of the three vacations.

The expense is at times urged as a reason for not scrubbing floors, but once a week should be strictly adhered to in the case of infants' departments and special schools, and on no account should the floors of senior departments be scrubbed less than once in three weeks.

Windows.—Windows should be cleaned when necessary; dirty windows, besides being unsightly, decrease the amount of light entering the room.

Walls.—The walls should be wiped down frequently and washed three times a year. There should be no ledges or projections permitting the lodging of dust, etc.

All *blackboards* should be cleaned with damp dusters; they should be provided with a trough to catch the chalk.

Advantage should be taken of the holidays to give the whole of the premises a very thorough cleaning, not omitting the insides of cupboards, etc.

Playgrounds should be swept with frequently damped brooms, all windows being closed; asphalt playgrounds should be washed over with a hose-pipe at least once a week. In all playgrounds any fæcal matter accidentally introduced should be removed as soon as possible and without fail at the end of the day.

HOSPITALS

The Provision of Isolation Hospitals

In the eighteenth century, and indeed before that period, isolation of infectious cases seems to have been practised in certain instances in lazarettos in connection with quarantine arrangements, but it was not until the latter half of the nineteenth century that isolation hospitals were provided on any considerable scale. The growth of the isolation system in the latter part of that century will be appreciated by reference to the history of infectious hospitals in London. Until the year 1867 the London Fever Hospital and the Highgate Small-pox Hospital were the only existing special isolation hospitals, and they were primarily devoted to the treatment of paying patients, no other special hospitals being available for the poorer members of the community suffering from infectious disease; thus the persons specially needing to be provided for were dependent upon the workhouse or the general hospital, while, to a large extent, owing to the insufficiency of the accommodation available, such persons were of necessity treated in their own homes, practically no attempt at their isolation being made.

The evils attendant on this system became so manifest that in 1867 the Metropolitan Asylums Board was constituted and empowered to make the necessary provision. At first it was thought that it would be sufficient to construct two permanent fever hospitals, together with two permanent small-pox hospitals, and two sites (Homerton and Stockwell) were secured, and the erection of a fever and small-pox hospital on each site was commenced. A third site, at Hampstead, was also shortly afterwards acquired. An outbreak of relapsing fever, in 1869, necessitated the erection of temporary huts on the Hampstead site and in the grounds of the London Fever Hospital, and in 1870 and 1871 the great small-pox outbreak occurred, and, as result, all available accommodation was absorbed, and a hospital ship, moored off Greenwich, was fitted up and used. Later epidemics of small-pox, in 1876 and subsequent years, led to the acquirement of additional sites. It was now noted, however, that small-pox was apt to become especially prevalent in areas surrounding the hospitals in which small-pox patients were aggregated.

Aerial Diffusion of Small-pox—Power's investigations with regard to the behaviour of small-pox, in the neighbourhood more particularly of the Fulham Hospital, in 1881 and years immediately preceding, directed special attention to this matter. He found that, dealing with fortnightly periods in the years 1877–81, no sooner did the number of recorded admissions to the institution exceed 35 or 40, than the influence of the hospital upon the surrounding population began to manifest itself. The relation between use of the hospital and manifestation of excessive small-pox in its neighbourhood was not, however, demonstrable when the hospital was employed for convalescents only; the reason being that small-pox patients are most highly infectious just after the appearance of the rash.

A "special area," included in a circle of one mile radius, having the hospital as a centre, was selected; this area was divided up into four others by concentric circles of a ¼-mile, ½-mile and ¾-mile radius respectively, each of these circles also having the hospital as a centre. The facts admitted of being tabulated as follows:

Admissions of Acute Small-pox to Fulham Hospital, and Incidence of Small-pox upon Houses in Several Divisions of the Special Area during Five Epidemic Periods.

Cases of acute Small-pox admitted.	In epidemic periods since opening of hospital.	Incidence on every hundred houses within the special area and its divisions.				
		On total special area.	On small circle 0–¼ mile.	On first ring ¼–½ mile.	On second ring ½–¾ mile.	On third ring ¾–1 mile.
327	March, 1877, to end of 1877.	1·10	3·47	1·37	1·27	·36
714	Jan., 1878, to Sept., 1878 .	1·80	4·62	2·55	1·84	·67
679	Sept., 1878, to Oct., 1879 .	1·68	4·40	2·63	1·49	·64
292	Oct., 1879, to Dec., 1880. .	·58	1·85	1·06	·30	·28
515	Dec., 1880, to April 2, 1881.	1·21	3·00	1·64	1·25	·61
2,527	Five periods.	6·37	17·34	9·25	6·15	2·56

The "very exact and very constant" gradation in the intensity of incidence upon houses, at increasing distances from the hospital, was found not to be explicable as a result of "recognised communications of the establishment with the outside world." Thus, "houses upon the chief lines of human intercourse with the hospital" had not suffered more than other houses, and the ingoings and outgoings of various classes of persons did not suffice to explain the phenomena. Power was led to conclude that direct atmospheric agency had been operative in promoting spread of the disease, and his report (published in the Tenth Annual Report of the Medical Officer of the Local Government Board) refers to "weather circumstances" which appeared to have favoured such atmospheric conveyance of infection, and to certain other problems arising on examination of an hypothesis of aerial diffusion of small-pox. These inquiries led to the appointment of a Royal Commission in 1881, to consider "the conditions and limitations under which the hospitals provided by the Managers should be continued"; and among the recommendations made by the Commissioners were the following: The provision of hospital accommodation for infectious disease should be entirely disconnected from the poor-law; cases of infectious disease should be notified to the medical officer of health of the district in which the patient resides; small-pox should be treated in hospitals established in isolated situations on the banks of the Thames, or in floating hospitals on the river itself; and convalescent hospitals should be established at some distance in the country.

The results of further inquiries on the aerial spread of small-pox are reported in the Fourteenth, Fifteenth and Sixteenth Reports of the Medical Officer to the Local Government Board. These and similar inquiries by Barry at Sheffield, Murphy at St. Pancras, Niven at Oldham and Evans at Bradford, provide strong evidence in favour of aerial spread. On the other hand, instances of the non-occurrence of the phenomena observed at Fulham in 1881 have been cited, but, of course, mere negative evidence in this connection is beside the mark. The argument has been advanced that proximity to a small-pox hospital means difference in character of population of such a sort as to favour prevalence of the disease; this suggested explanation, however, cannot be regarded as meeting the large body of evidence collected by Power and others. The objectors to aerial dissemination limit themselves, nowadays, for the most part, to rejecting the possibility of such dissemination over long distances, that is to say, they accept, as a rule, the hypothesis that the disease can spread in the near neighbourhood, but look upon excessive incidence of small-pox, at greater distances from the hospital, as being bound up with questions of human intercourse, ambulance traffic, and the like.[1]

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[1] The subject is fully discussed at p. 269, "The Sources and Modes of Infection," C. V. Chapin. A certain number of cases have come before the courts in which it has been sought to obtain an injunction, preventing the use of a particular hospital for the treatment of small-pox, on the ground of danger to health. In the instances of hospitals at Withington in 1893, at Guildford in 1895, and at Ossett in 1898, injunctions thus applied for were refused.

To return, however, to the recommendations of the Commission of 1881. An Act of Parliament was passed removing all civil disabilities attaching to admission to hospitals of the Metropolitan Asylums Board. Notification was tentatively introduced in 1889, its adoption was (except in London) made in the first instance permissive throughout the country generally. The system had previously been introduced in a few towns under local acts; it was made compulsory in London in 1889, and throughout the country in 1899. Three floating hospitals were ultimately established in Long Reach, some seventeen miles below London Bridge, and a temporary camp (and later permanent accommodation) was provided in an isolated situation at Gore Farm, near Darenth. Convalescent hospitals have also been constructed. The removal by water to the hospital ships was effected in special ambulance steamers, and the land ambulance system was soon developed and extended to the removal of cases, other than small-pox, to the ordinary hospitals of the Board.

In 1887 an Order of the Local Government Board empowered the Asylums Managers to receive all persons suffering from small-pox or fever, whose removal was applied for by any "duly qualified medical practitioner" (the regulations made under the Act of 1867 originally made it necessary for the Poor-Law officers to sign the admission orders), and in 1889 the Managers were empowered by Act of Parliament to admit (" subject to such regulations as the Local Government Board from time to time made ") any person "believed to be suffering from fever, small-pox, or diphtheria"; finally the Public Health (London) Act, 1891, threw the cost of maintenance of non-pauper patients upon the county rate. The effect of thus completely removing the "stigma of pauperism," of making the treatment gratuitous, and of extending the facilities afforded to diphtheria, would in any case have been marked; the changed conditions coincided, however, with the introduction of notification. The great advantages incidental to hospital treatment speedily appealed to the public, and the percentage of cases admitted to the hospitals increased rapidly.

Fears at first entertained that serious injury would result, from conveyance of sick persons from their houses to the hospitals, have been found, in the light of actual practice, almost wholly groundless. In many other large urban centres a good deal of attention has been given to the subject; thus, in Glasgow the first municipal hospital was opened as early as 1865, and already in 1881 the Local Authority resolved "that all classes of the citizens suffering from infectious disease should be treated in hospital without any charge being made therefor." Section 131 of the Public Health Act of 1875 authorised the provisions of hospitals by sanitary authorities generally.

An important report on the use and influence of hospitals for infectious diseases was prepared by Thorne Thorne, in 1880–81, for the Local Government Board (Supplement to the Tenth Annual Report of the Medical Officer of the Board). Attention was specially directed to the fact that if isolation hospitals are to be of use their accommodation must be ready beforehand. Numerous instances were encountered in the course of the inquiry in which epidemics had "evidently been prevented by the isolation of first cases of infectious disease." On the other hand, the "hospital hastily run up, when small-pox or fever was making head in the district," had proved an undoubted failure. The finding of the report with regard to the emergency hospital is as follows: "It is often not ready for occupation until the immediate cause of its erection has passed by; it provides accommodation of a very indifferent sort; it fails, almost without exception, to meet the permanent requirements of the district, even when in amount it turns out to be more than the district needs; and thus the object of the hospital, as a part of the sanitary defences of the district, is often attained in a very imperfect manner and at a needlessly large cost." Another notable result of the inquiry was the elicitation of the fact that there was no evidence to show that fevers (scarlet, typhus, and typhoid) or other infectious disease spread from the hospital to the surrounding neighbourhood.

Memorandum on Provision of Isolation Hospitals—A Memorandum issued by the Local Government Board in 1888 (re-issued in 1895), sets out the general principles which should be held in view by all authorities about to establish isolation hospitals for their districts. This Memorandum states that: "For a town the hospital provision ought to consist of wards in one or more permanent buildings, with space enough for the erection of other wards, temporary or permanent. Considerations of ultimate economy make it wise to have permanent buildings sufficient for somewhat more than the average necessities of the place, so that recourse to temporary extensions may less often be necessary. In any case, it is well to make the administrative offices somewhat in excess of the wants of the permanent wards, because thus, at little additional first cost, they will be ready to serve, when occasion comes, for the wants of temporary extensions."

As regards the number of cases for which permanent provision should be made, the Memorandum states that no fixed standard can be laid down; much "must depend upon various considerations, among which the size and growth of the town, the housing and habits of its population, and the traffic of the town with other places, are the most important." A rough rule has been formulated to the effect that at least one bed for every 1,000 persons should be provided: it may be noted, however, that the provision in London during recent years has been considerably in excess of this standard; while, on the other hand, in sparsely populated districts, and particularly in places where the population is largely well-to-do, it may be found that one bed for every 1,500 or 2,000 inhabitants, provided temporary extension can be made if needed, will prove sufficient. The number of beds required depends partly on the age constitution of the population, the greater the number of children the greater the number of beds required, partly on economic and housing conditions, these governing the percentage of fever cases nursed at home.

DISPOSAL OF INFECTIOUS PATIENTS

The circumstances are often such that the patients cannot be allowed to remain at home. To prevent the spread of infection patients with small-pox, typhus or plague must be removed to an isolation hospital, as must those with scarlet fever or diphtheria when the patient cannot be given a separate room at home. Scarlet fever or diphtheria patients who have as contacts either persons engaged in the handling of milk or school teachers cannot be allowed to remain at home lest these persons should contract the disease in so mild a form as to remain undetected or in the absence of precautions carry the infection. For the protection of women about to be confined against puerperal fever any patient in contact with them suffering with scarlet fever or erysipelas should be removed to hospital. Patients with typhoid fever are best removed to an isolation hospital; in practice they are frequently removed to a general hospital early in the disease and continue to be nursed there after the diagnosis has been established.

The Ministry of Health do not object to the nursing of typhoid fever in general hospitals if precautions which satisfy the M.O.H. are taken to prevent the spread of infection. In this connection the M.O.H. should bear in mind that there is a considerable danger of infection of nurses who in general hospitals are seldom protected against attack by vaccine as a routine measure.

Patients suffering from scarlet fever or diphtheria who are resident in general hospitals, convalescent homes, boarding-schools, hotels and boarding-houses must be transferred to isolation hospitals. Patients with other infectious diseases such as erysipelas or puerperal fever are received into some isolation hospitals; cases of measles and whooping-cough are admitted into Metropolitan Asylums Board infectious hospitals when accommodation is available; cases of measles, mumps and whooping-cough in boarding-schools are commonly nursed in hospital wards in the school grounds or are removed to private nursing homes. In every general hospital, particularly in hospitals for children, provision should be made for the isolation of suspicious cases of infectious disease. Apart from the prevention of the spread of infection, patients suffering from scarlet fever in a severe form, diphtheria, typhoid fever, ophthalmia neonatorum, measles with complications, and influenzal pneumonia are admitted for the better treatment and nursing of the patients. The Local Government Board advised the provision of accommodation at the isolation hospital for cerebro-spinal fever, acute poliomyelitis and encephalitis lethargica. These diseases are frequently nursed in general hospitals with no subsequent attack among fellow-patients; in cerebro-spinal fever the important point is that all patients from as large an area as possible should be admitted to one hospital, as considerable experience is necessary for the proper treatment of the disease by intrathecal injections of serum.

GENERAL AND ISOLATION HOSPITALS

A hospital has been described by Sir John Simon as "an establishment which never rests from fouling itself," hence its construction and surroundings require to receive, in a special degree, attention with regard to matters of lighting, ventilation, aspect, etc., which has already been noted as necessary in the case of dwelling-houses generally.

General and isolation hospitals are constructed on similar lines, but in isolation hospitals the arrangements must allow of the separation of patients suffering from various infections from one another and from the public; many are very much smaller than general hospitals. The ideal site is on a gentle southerly slope protected on the north and east by higher ground or wooded land. Whilst low-lying sites are undesirable, too great relative elevation, particularly on the south and west coasts of this country, may result in undue exposure to south-westerly gales; such an exposure makes the control of ventilation difficult and prevents the convalescents taking light exercise. The subsoil should be dry, heavy clay and water-logged land should be avoided. The extent of the site except in the case of small hospitals should not be less than two acres.[1]

The ward blocks should lie from N. by N.N.E. to S. by S.S.W., so giving the wards sunlight throughout the day with a rather fuller exposure in the morning when warmth and brightness are most required. Lofty structures of many storeys should be avoided as far as practicable, and the buildings should be detached. Tenon, in 1788, drew attention to the evils of free intercommunication between hospital buildings, in connection with the old Hôtel Dieu in Paris, a vast pile designed to accommodate upwards of 3,000 persons, having the most infectious departments placed in the middle of the building, and constituting practically a huge ward. Such a pile was, as this writer said, more fit "to destroy than to establish and preserve health." Tenon urged that intercommunication between wards should be as far as possible prevented. In large modern hospitals, with a view to attaining this object, what is known as the "pavilion system" is usually adopted. The pavilions are often on two floors and united by a corridor; the administrative buildings are centrally placed, but detached from the ward blocks.

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[1] See "Construction, Equipment and Management of a General Hospital." D. J. Mackintosh.

In isolation hospitals the pavilions are preferably on one floor, not connected by covered ways and situated at least 40 feet from the boundary wall.

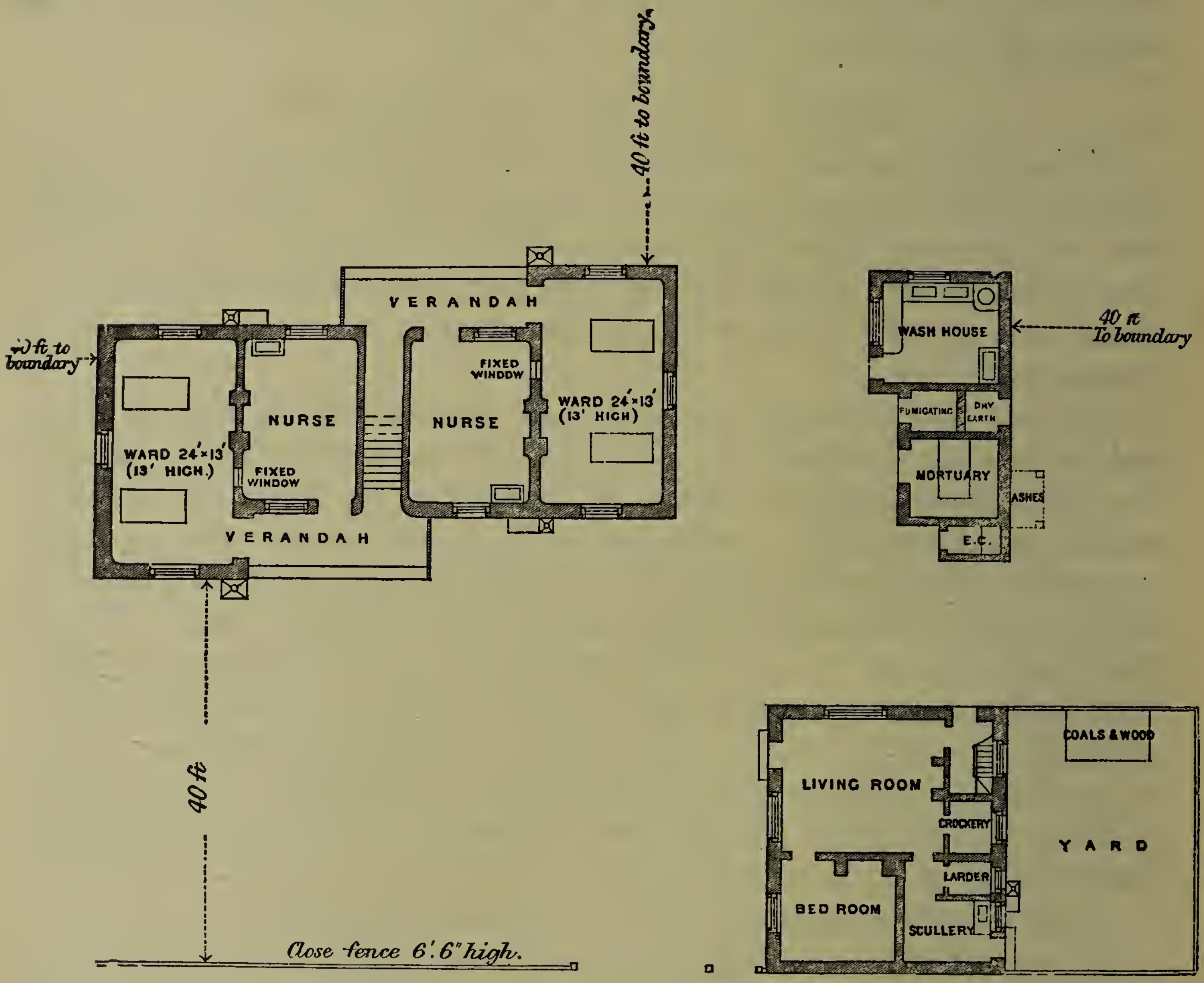

FIG. 70.—A small isolation hospital, designed to accommodate two patients of each sex. A caretaker's cottage is also shown.

The Memorandum referred to is accompanied by plans illustrating the sanitary requirements of small hospitals for infectious diseases. The simplest form of hospital should comprise at least (1) an administration block; (2) a block for patients; and (3) a washhouse, mortuary, and disinfection-house block. In Fig. 70 the ward block provides for the accommodation of only four persons, two of each sex.

A somewhat larger hospital building, providing for ten patients, and admitting of isolation of two distinct diseases, as well as of separation of the sexes, is also shown. Fig. 71 is a plan of a small pavilion, adapted to receive male and female patients, suffering from different forms of infectious disease.

In Fig. 70 an earth-closet, E.C., is indicated as the means of excrement disposal (earth-commodes are suggested for the wards); water-closets are, of course, to be preferred where efficient sewers are available. In any case, the Memorandum prescribes that an interval of 40 feet shall be interposed between every building used for the reception of infected persons or things, and the boundary of the hospital site; moreover, "this boundary should have a close fence of not less than 6 feet 6 inches in height (to prevent the easy escape of patients and illicit traffic with the outside public). The 40-feet interval should not afterwards be encroached upon by any temporary building, or other extension of the hospital. In the construction and arrangement of such temporary buildings as may at times be wanted in extension of the permanent hospital, the same principles should be held in view."

In the medium-sized isolation hospital the principal entrance is controlled by the administrative block and in larger hospitals still by a lodge usually occupied by the head porter. Houses in the grounds or the near vicinity are with advantage provided for the "engineer," disinfector and the ambulance driver.

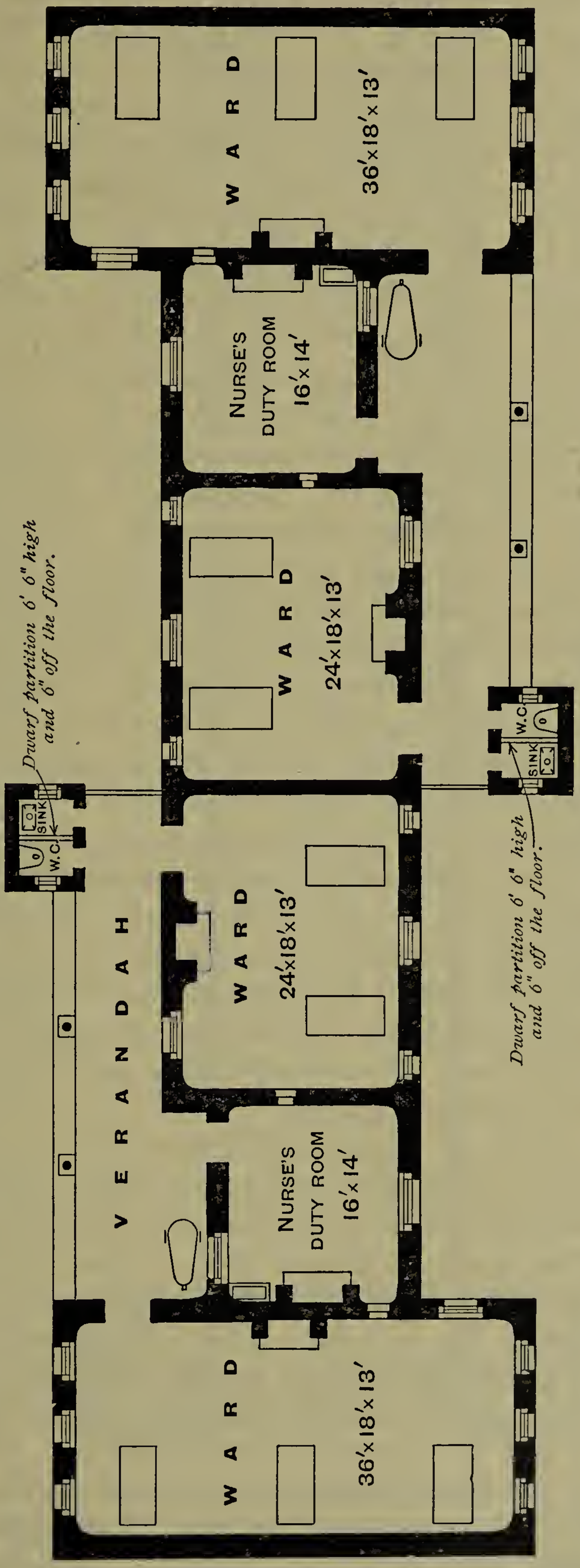

FIG. 71.—Plan of a block for ten beds.

It is preferable for two or three of the male resident staff to be married men living in the grounds so that they are readily available for emergency work and also can exercise a certain amount of supervision over the grounds; in practice it is found that their children do not contract infections from the patients if direct contact with patients is avoided. In hospitals of up to 150 beds the administrative block usually contains quarters for the matron, nurses and maids, a detached suite of rooms for the resident medical officer, the dispensary, office, stores and kitchen, the last being preferably a one-storeyed wing with top ventilation. Near the centrally placed administrative block is situated in one building, the laundry, boiler-house and disinfecting station. Secluded from other buildings and the commonly used paths are the mortuary and post-mortem room. In many hospitals a building providing sleeping accommodation for night nurses is placed in a quiet part of the grounds. Discharge blocks should not be built as it is best to discharge direct from the wards, the cleansing bath having been given on the previous evening, thus preventing chills and colds.

The space between the blocks should be such as to allow of adequate lighting and ventilation of the wards. Even when the cost of land is great, the essential principle of separating wards and administrative buildings should still be observed: any operating-room should be disconnected from the wards; the mortuary should be removed from other buildings; the laundry and out-patient departments should not be in aerial communication with wards.

The ward unit is usually rectangular in shape, 24 to 30 feet wide and from 30 to 100 feet in length. The floor space per bed in general hospitals should be from 100 to 125 square feet; this amount may with advantage be increased to 150 square feet in wards in which special cases are treated and in wards in which clinical teaching is carried on; the corresponding cubic space should be at least 1,500 cubic feet per patient.

In fever wards with several beds, for each bed 12 feet of wall space, 144 square feet of floor space, and 2,000 cubic feet (in no case less than 1,872 cubic feet) of air space are required. In calculating cubic space no height over 13 feet should be taken into account. The cubic space for a child should not be less than two-thirds that allowed for an adult (Thorne). In single bed wards with efficient cross ventilation, 144 square feet and 1,440 cubic feet is required by Plan D; the Ministry of Health are even prepared to accept 12 feet × 10 feet for such wards.

Nursing arrangements are best facilitated with wards containing from 24 to 28 beds. In Fig. 72 the ward contains 24 beds, each of which is placed, as is desirable, between two windows; it will be noted that the end beds have a window on each side of them, and this arrangement is desirable, as otherwise the space occupied by the end beds would be less favourably circumstanced, as regards ventilation, than that in the neighbourhood of other beds.

For lighting purposes the total area available should be from one-sixth to one-seventh of the floor area; the windows should extend from 2½ or 3½ feet from the floor level to within 6 inches of the ceiling.

Ventilation should be provided for, to the extent of at least 3,000 cubic feet per head per hour. In this country reliance is, as a rule, mainly placed upon the ventilation afforded by open windows, as it is found that "on about 300 to 330 days in the year it is possible to open the windows of a hospital ward without injury to the patients." In the more recently constructed hospitals, cross ventilation is secured: the windows are fitted with double-hung sashes, and a deep fillet at the sill is often provided, with a view to the admission of air between the upper and lower sash, without causing draught at the sill level. In addition to such window ventilation, it has, however, been found desirable to arrange for the admission of warmed air by ventilating stoves, which provide an open fireplace in the centre of wards, and by openings so situated that the entering air is warmed by radiators,[1]

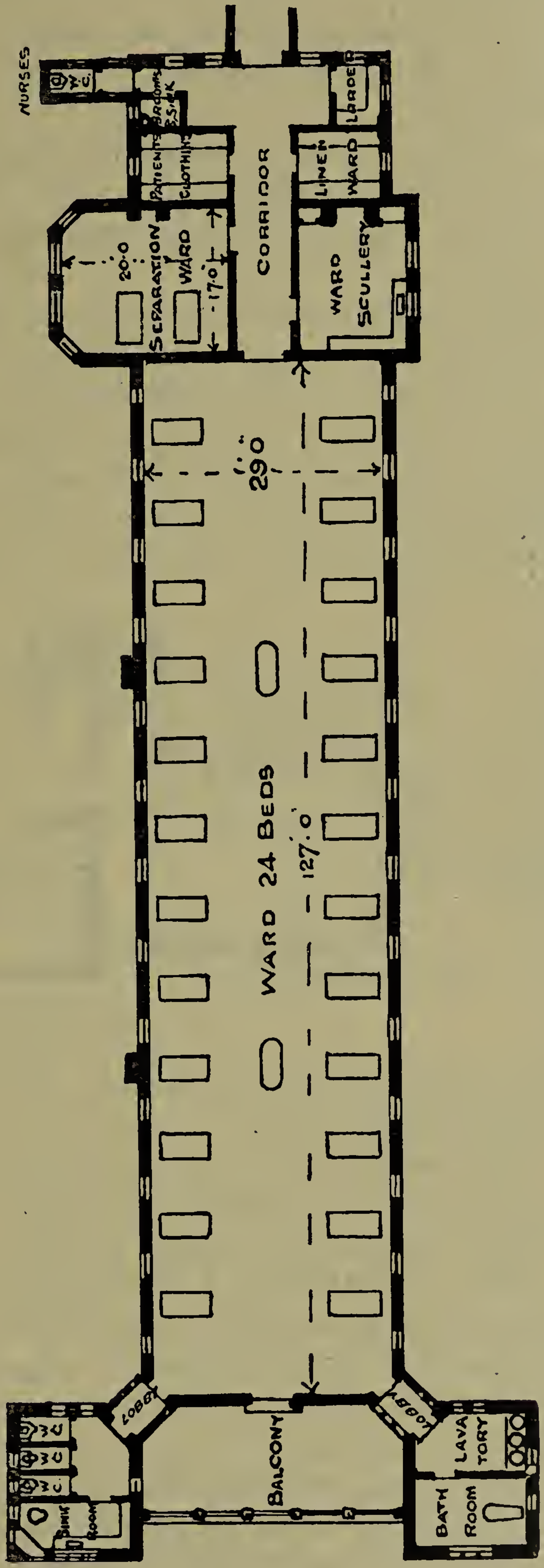

FIG. 72.—Plan of ward limit (*after Keith Young*).

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[1] In low-pressure systems 12 feet of hot-water piping is allowed for each 1,000 cubic feet of air; in high-pressure systems 8 to 9 feet. The disadvantage of the high-pressure system is the risk of the guards being removed and the patients receiving severe burns. The best system of heating is a low-pressure system with accelerated circulation which allows of smaller pipes and radiators.

usually the main source of supply of heat to the ward. As regards extraction of air, fireplaces are mainly relied upon, and in addition vertical shafts in which an upward current of air is produced, by coils of steam or hot-water pipes, have also been provided in some instances.

In this country artificial systems of ventilation are only very occasionally installed in hospitals, the unimpeded entrance of fresh air being easy to obtain by open windows and doors. Except in cold weather the patient should depend for heat on sufficient clothes and blankets and if necessary hot-water bottles. If a warmer atmosphere is required for a particular patient treatment should be provided in a side ward. The radiant heat from an open fire is cheering and the convection of heat from radiators of value in bitter weather, but in a properly ventilated ward neither of these sources of heat should make much difference to the temperature of the air. The temperature of the ward should usually not be more than 10° F. above that of the external air, the minimum ward temperature advisable being 45° F.

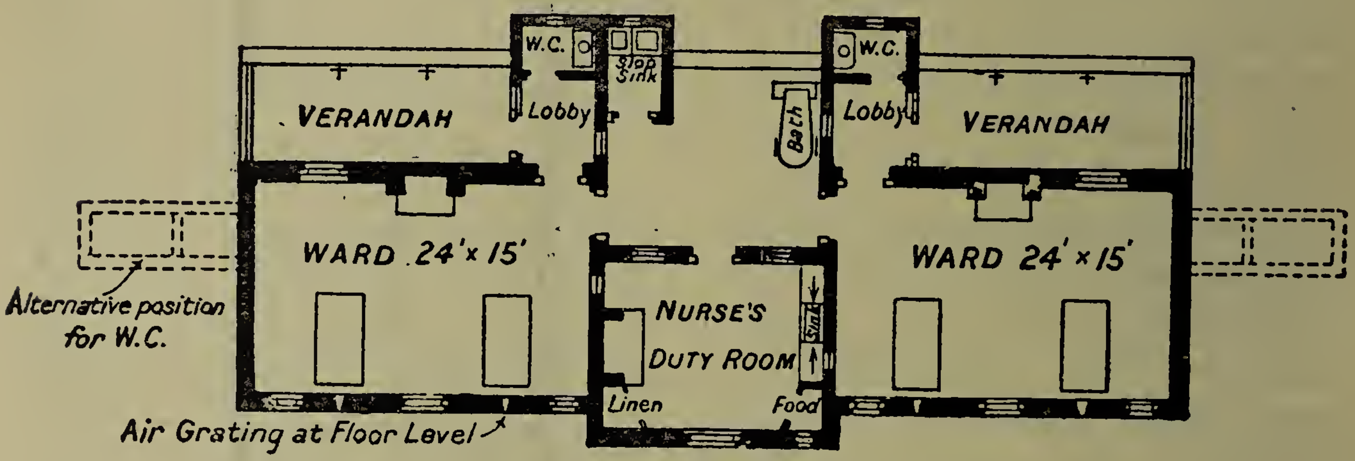

FIG. 73.—Plan B of the Local Government Board's Model.

The water-closets and lavatories should be disconnected, by cross-ventilated lobbies, from the ward. One water-closet and bath are provided for every twelve patients.

The construction of the ward should be such as to allow of it being readily cleansed; the floors, if of wood, should be made of tongued and grooved boards or blocks, well-seasoned so that shrinkage will not occur. Solid floors of cement or terrasso may crack owing to sinking of the ground; complaints are sometimes made of their being cold and tiring to the feet.

The floors should be of fireproof material, formed by iron joists embedded in concrete, and with the wooden floor laid solid upon the concrete surface, no intervening space capable of harbouring dust or germs being left; the boards should be stained and polished, so as to obviate need for continual washing. The walls should be impervious, hard and smooth, and if painted and glazed are easily cleaned. The dado may with advantage be covered with glazed tiles; glazed bricks with their relatively wide joints are not so satisfactory. The ceilings are usually distempered. To avoid all crevices in which dust might lodge and to allow of easy cleansing the junctions of the walls with floor and ceiling should be rounded; the curve at the floor level should be small, as a large and extended curve prevents furniture, unless specially made for the purpose, being placed against the wall. Similarly no mouldings should be allowed on doors, windows and furniture.

From time to time it is convenient and necessary to isolate a patient, the paying patient, the patient with a mixed infection or one who develops a fresh infection, the patient requiring some special form of treatment or the dying patient. In general as well as in isolation hospitals each ward of twelve beds should have one or two side wards attached for special cases. In addition, in fever hospitals, there should be an isolation block designed on lines similar to plans B or D of the L.G.B.'s model; in this block at least one isolation bed should be provided for every ten beds in the hospital.

The arrangements should allow of the patients receiving open-air treatment and exposure to sunshine. Every ward should have doors opening on to verandahs or balconies; the doorways should be at least 3½ feet wide so as to allow of the easy passage of a bed. The beds should be made so as to be easily movable. Verandahs somewhat darken wards, but this drawback can be lessened by the provision of glass-roofed verandahs not reaching higher than the transomes of the windows, additional light being admitted to the ward by hopper windows above the transomes.

Bed and Cubicle Isolation—To promote economy in construction and staff and greater convenience in nursing, the experiment has been tried of the same nurse attending to patients suffering from different diseases, these patients being nursed in a common ward. The experiment was first carried out by Biernacki at the Eastern Hospital (M.A.B.); experience has subsequently shown that whilst cases of typhoid fever, mumps, diphtheria, rubella and more doubtfully whooping-cough[1] can be so nursed without spread, for septic cases of scarlet fever and early cases of measles before the rash has developed and of chicken-pox this method of nursing cannot be safely employed.

Infection is usually carried from one bed-patient to another by the hands of the nurse. In measles, scarlet fever and diphtheria, the nurse's hands are infected in cleansing the nose, mouth and

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[1] Placed in order of safety. Thomson in his recent book, "The Diagnosis and Treatment of Infectious Diseases," says: "Evidence was obtained which suggests that the infection of chicken-pox, measles and whooping-cough was conveyed (aerially) beyond 14 feet."

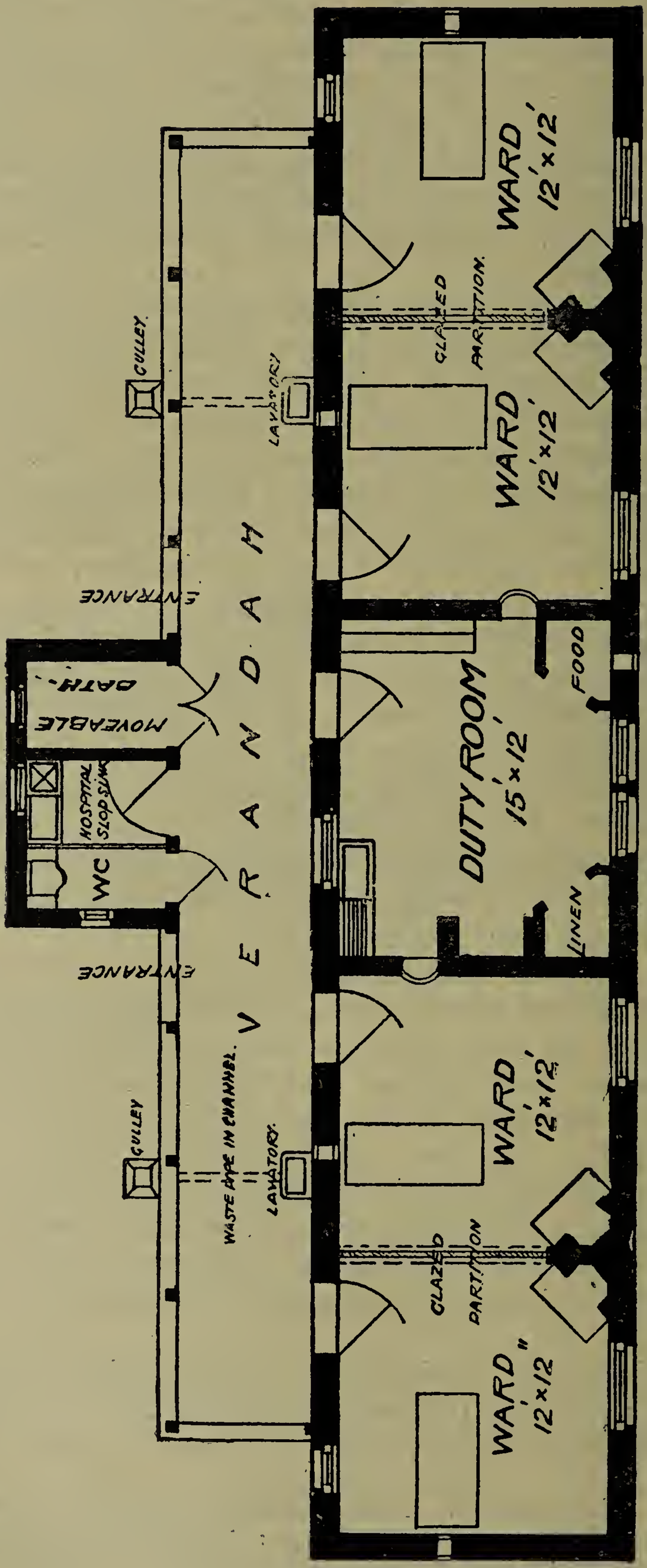

FIG. 74.—Plan D of the Local Government Board's Model.

throat of the patient; she may carry the infection on her hands directly to another patient, or indirectly on a handkerchief or towel; in typhoid fever and diarrhœa the nurse's hands are soiled when attending to the patient after the passage of a motion and subsequently the nurse touches and infects the food of another patient. Ringworm of the scalp is also spread by the nurse using a comb or hairbrush for more than one patient, also at times directly by the bad habit of patting child patients on the head. If the nurse washes her hands thoroughly or wears rubber gloves and disinfects them before attending to another patient this mode of spread of infection is prevented. There is no risk of the aerial spread of infection[1] from patient to patient (save, of course, in the case of acute small-pox, chicken-pox and measles) if certain arrangements are made. There must be at least 12 feet of wall space for each bed, the nearest edges of adjacent beds being at least 9 feet apart; between each of the beds there must be a window; the mattress must be 2 feet above the floor level and adequate ventilation must be maintained. But even if all these matters receive attention the patients themselves may spread infection by exchanging books or toys, pens and pencils, or even come into actual contact with one another. It is therefore evident that although different infectious diseases can be safely nursed in the same ward, for success every nurse working in the ward must be thoroughly trained in the routine, and be intelligent, careful and conscientious; also the patients must be continuously supervised. Bed isolation is the most promising way of nursing scarlet fever patients (in scarlet fever wards) as the nature of the secondary septic infections differ in the various patients and their transference from one to another may lead to disastrous results, especially in young children under five years of age. The transference of these secondary septic infections is probably also responsible for the prolonged infectivity of some of the hospital nursed cases.

Several modifications of bed isolation, pure and simple, are practised. Owing to the difficulty of carrying out the constant supervision required, glazed partitions have been placed between the beds. The surrounding of the bed with glass partitions produces the "cubicle" system. Each bed may occupy a compartment entered from a central corridor as in the Pasteur Hospital in Paris or from a verandah, *e.g.*, the Norwich Isolation Hospital. In the South-Western Hospital of the M.A.B. a large ward, 100 feet long and 28 feet wide, is divided into cubicles by glazed partitions. The cubicles open into a passage, 5 feet 6 inches wide, by double-hung doors which can be opened by the pressure of the knee. Separate linen overalls for the doctor and nurses and a distinct set of articles and appliances for the patient are provided in each of the cubicles. Lavatory basins are fixed in each cubicle so that the hands can easily be washed at once after touching the patient.

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[1] Chicken-pox needs a barrier of the order of the wall of a room, measles spreads easily from bed to bed; in both diseases the greatest risk of spread is in the first two or three days of illness.

Although bed and cubicle isolation can undoubtedly be practised with success, the high standard of nursing required militates against its general adoption and the usual practice of nursing different diseases in separate wards with special nurses for each disease is the surest method at present of avoiding cross-infection.

To avoid cross-infection and secondary infection among cases of the same disease the treatment of infectious disease in small wards has much to recommend it; the patient obtains all the advantages of the skilled nursing of the hospital and avoids the danger of secondary infections.

The Laundry—All linen soiled with fæces or urine, and pillow-slips soiled with the nasal secretion, are best placed in a tank of disinfectant solution just outside the wards. All other linen and articles for washing should be sent to the laundry dry. It would seem that there is no danger in passing all these articles together through the laundry. The following negative evidence would appear to be convincing: (1) in Brighton for the last thirty years a careful note has been kept of the laundries to which articles from infected houses have been sent prior to notification and in no instance has any spread of infection from a laundry been noted; also (2) 300 tuberculous and wasting children under 10 have been admitted to the isolation and tubercle wards, and although the linen from the scarlet fever and diphtheria wards has been laundried along with that from the above-mentioned patients no case of disease has been traced to this cause.

It is evident that common sense must be used, for instance it must be arranged that laundried articles must not come into contact with articles just brought from the wards. The doors of the receiving room and the distributing room should not be common or adjoin. In many hospital laundries time and money are wasted in arranging separate days for the separate washing of articles from different wards and from the staff.

Where temporary buildings must be provided at short notice to meet an emergency, wooden huts or galvanised iron structures have been utilised; tents have been erected in summer time, and portable hospitals constructed of what is known as Doecker's material (a leather-like waterproof material) have also been employed. The temporary fever hospital at Tottenham, which was completed in 1892 for the Metropolitan Asylums Managers in six weeks, consisted of wooden structures upon brick piers, raised upon concrete platforms, in most cases extending about 6 feet beyond the walls. These buildings were thus described: "The floors are in double thickness, with a layer of felt between; the walls are of timber framing, filled and weather-boarded outside, and match-lined inside; and the roofs are match-lined, boarded, and covered with galvanised corrugated iron. The whole of the buildings are warmed by steam pipes or radiators worked by the central boilers, which also supply steam to the kitchen laundry."

Finally, it remains to note as regards infectious hospitals that it is especially important that all dressings, poultices, etc., should be so dealt with as to avoid spread of infection, and that infected clothing should be adequately disinfected. Proper disinfecting apparatus should therefore be available, and a destructor furnace for burning refuse material is a desideratum.

Careful supervision requires to be exercised over visiting arrangements. On Saturday or Sunday afternoons the two nearest relatives of each patient should be allowed to visit the fever hospital and see and talk to the patients for a definite short time, *e.g.*, 20 minutes, through the closed windows, after which they should have an opportunity of interviewing the medical superintendent. Such arrangements give satisfaction to the parents and save much correspondence. Patients' friends should only be admitted to the wards in critical cases, the appropriate precautions being taken to prevent spread of infection. The Metropolitan Asylums Board advise visitors to partake of food before entering a hospital and not to enter the wards when in a weak state of health or in an exhausted condition. When in the wards they must carefully avoid touching the patient or exposing themselves to his breath, and they must not sit on the bed or handle the bed-clothes.

Visitors when in the wards must wear a wrapper provided by the Board, covering their clothes and heads, and wash their hands and faces with soap and water before leaving the hospital, or use such other mode of disinfection as may be directed by the medical superintendent. No visitors should be allowed at a small-pox hospital except to see dying patients and then only if they have been recently successfully vaccinated. Due precautions are necessary in connection with the discharge of patients. Care should be exercised, moreover, with regard to tradesmen's visits, and indeed all necessary intercourse with the outside world.

SMALL-POX HOSPITALS

While the provision of a 40-feet interval is deemed to afford sufficient security in the case of buildings devoted to the reception of cases of infective fevers other than small-pox, the case is far different when this disease has to be dealt with. The Memorandum[1] prescribes "with a view of lessening the risk of infection," that a local authority should not contemplate the erection of a small-pox hospital :

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[1] Memorandum on the Provision of Isolation Hospital Accommodation by Local Authorities, L.G.B., Jan., 1895.

"1. On any site where it would have within a quarter of a mile as a centre, either a hospital, whether for infectious diseases or not, or a workhouse, or any similar establishment, or a population of 150 to 200 persons.

"2. On any site where it would have within half a mile of it as a centre, a population of 500 to 600 persons, whether in one or more institutions, or in dwelling-houses. It must also be understood that even where the above conditions are strictly fulfilled, there may be circumstances under which the erection of a small-pox hospital should not be contemplated. Cases in which there is any considerable collection of inhabitants, just beyond the half-mile zone, should always call for special consideration."

It will be seen that these conditions preclude the provision of buildings for the isolation of small-pox on the same site as that on which an isolation hospital for other forms of infectious disease is constructed, and this need of providing dual sites has led to difficulty, especially in the case of small districts. Under the Isolation Hospitals Act, 1893 (amended by that of 1901), County Councils were empowered, on representation being made to them, to combine sanitary districts into Hospital Districts, and to contribute out of the County Rate towards the expenses of an isolation hospital.

SANATORIA

Sanatoria are provided for the treatment of "early" cases of pulmonary tuberculosis and for the educational treatment of the more favourable of the chronic cases. They should contain not less than 100 beds.

They are usually situated in a country district, but to prevent difficulties in administration should not be too far away from a satisfactory railway service.

An upland situation with a slope, sheltered from prevailing winds, is desirable ; the soil should be dry and permeable and the air pure and dry and free from the dust of main roads or a sandy soil. Sites liable to fogs such as those on a clay soil, damp situations and the bottom of valleys should be avoided ; in this country mountain sites are unsuitable on account of their wet and misty climate ; the seaside is suitable for surgical but not for pulmonary tuberculosis.

The area of the site should be large enough to provide facilities for exercise and employment of patients, the minimum is one-fifth of an acre for a patient ; of late years the recommendation of the Departmental Committee—half an acre per patient—has not infrequently been exceeded. Facilities for water supply and drainage must be considered.

In all sanatoria a few single-bed wards should be provided for cases which require much nursing; febrile patients confined to bed are often placed in a large ward.

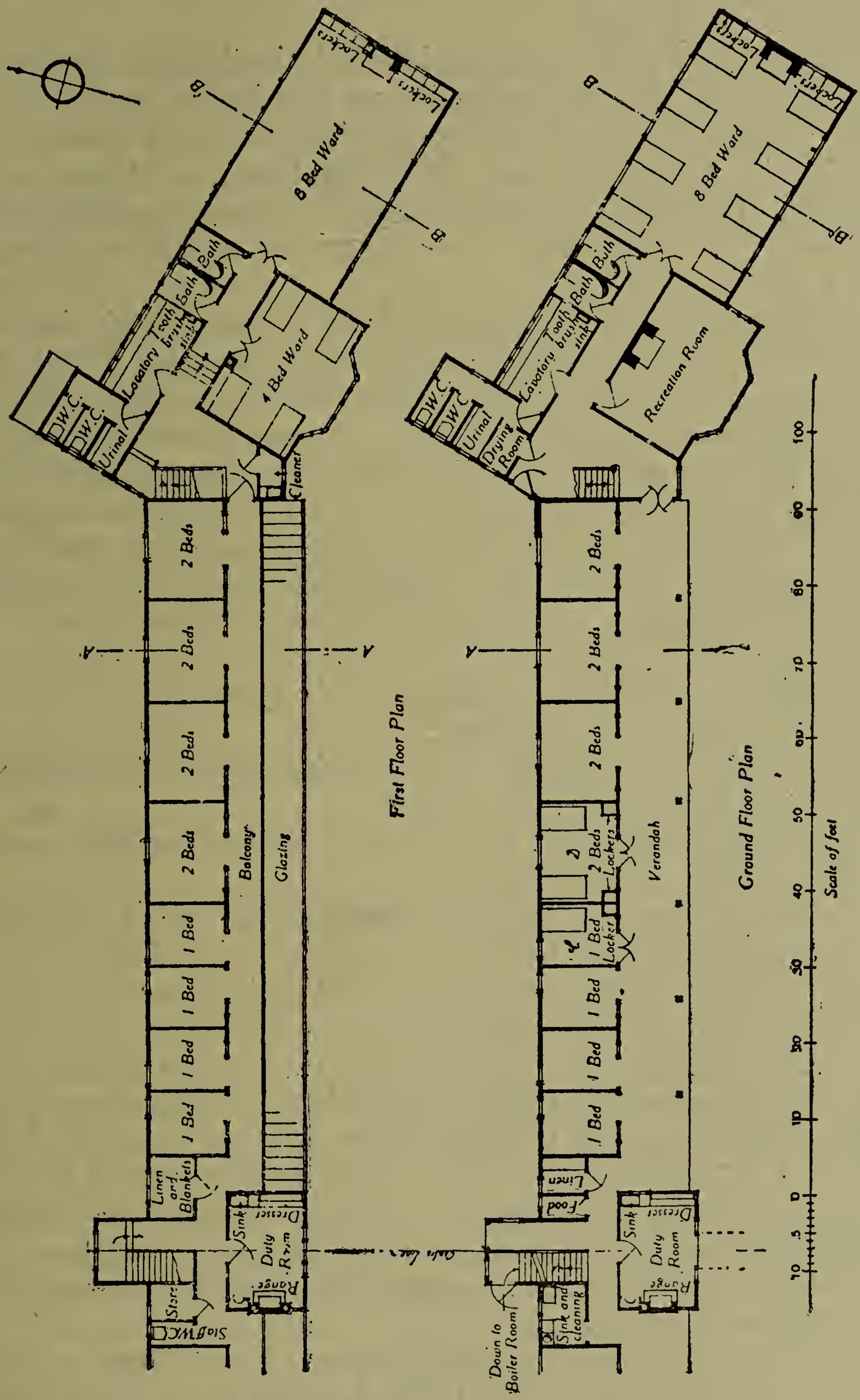

FIG. 75.—Plans of ground floor and first floor of a two-storeyed pavilion for a sanatorium.

These patients should be accommodated in a part of the institution set apart for the purpose; it should be quiet and not liable to disturbance from the passage of other patients and sufficiently near to the kitchen to allow of easy service. About 20 per cent. of the sleeping accommodation should be in this part of the institution.

Patients in the afebrile stage—convalescents—are suitably accommodated in a large ward.

When the verandah accommodation is inadequate shelters are often provided so that the patients may live in the open air in the daytime; these may be used for sleeping, but on account of the difficulties in supervision and administration should not exceed 10 per cent. of the total accommodation. They are especially suitable for patients who will shortly be sleeping in similar shelters after their return home.

In buildings designed as sanatoria one of the earliest plans used in this country was a building (facing south) consisting of two wings either in one line or inclined to one another at an obtuse angle and united by a central block containing a dining-hall and the administrative departments. Each wing consisted of a row of small wards containing one or two beds with a verandah in front and a corridor behind, permanently open means of ventilation being provided at the back and front of the ward. If wood were used for their construction the buildings were only one storey high, if stone or brick, two storeys high.

The minimum standards of floor and air space sanctioned by the Ministry of Health are as follows:

Adults (pulmonary), 64 sq. ft. per patient and 8 ft. between the centres of the beds.

Adults (non-pulmonary), 64 sq. ft. per patient and 6 ft. between the centres of the beds.

Children (pulmonary), 50 sq. ft. per patient and 6 ft. between the centres of the beds.

Children (non-pulmonary), 50 sq. ft. per patient and 5 ft. between the centres of the beds.

The Memorandum of the L.G.B. of 1914 states that "it will usually be unnecessary to heat the patients' quarters except the dining-hall and some of the rooms for patients requiring special nursing. A system of low-pressure hot-water heating will be found most economical for this purpose." In some institutions abundant heating apparatus will be found provided to supply the loss of heat of the patients caused by the movement of air and the free communication with external air.

Recreation rooms are required for use on wet days or winter evenings; these are conveniently added to the part of the building used by the convalescent patients.

Plans for sanatoria have not yet become stereotyped; converted Army huts among other forms of construction have been found useful.

When additional accommodation is required it is most economically supplied by the enlargement of the existing institutions rather than by the erection of new buildings. Hence all buildings for tuberculous patients should be planned with a view to expansion. The arrangements should allow of separate treatment for men and women; children should be accommodated in a separate pavilion.

In the absence of accommodation of the best type—the country sanatorium—no harm ensues from the combination of accommodation for tuberculous patients with that for other infectious diseases provided no contact direct or indirect occurs between the two sets of patients.

The power to provide sanatoria is given by Section 131 of the Public Health Act, 1875, which enables sanitary authorities to provide hospitals or temporary places for the reception of the sick. Although the Isolation Hospitals Acts, as they stand, relate only to the diseases mentioned in the Infectious Diseases Notification Acts, they can be extended to tuberculosis by an Order of the County Council with the consent of the Ministry of Health. County Councils are enabled to provide sanatoria by the National Insurance Act, 1911.

The extent of the accommodation required for sanatorium treatment was estimated by the Departmental Committee on Tuberculosis as one bed for every 5,000 inhabitants in addition to hospital accommodation for advanced cases and for purposes of education and observation, but this estimate has been largely exceeded in some areas.

Hospitals are required for chronic patients who need periods of treatment to restore them to a degree of working capacity at least temporarily, also for very acute or for advanced cases which are a source of danger to others if kept at home. These hospitals should be situated as near as possible to the homes of the patients.

The Ministry of Health only approves of the treatment of pulmonary tuberculosis in general hospitals if tubercle bacilli are absent from sputum or when the patient is admitted for observation or in an emergency, *e.g.*, hæmoptysis. Accommodation for the observation of patients with a view to definite diagnosis or the determination of the form of treatment required should be provided near the homes of the patients.

Combined institutions are those in which patients in all stages of the disease can be treated; they must in consequence be situated near a town and be readily accessible.

The Memorandum of the L.G.B. on the Provision of New Residential Institutions for the Treatment of Pulmonary Tuberculosis (1914), states that in a combined institution about 36 per cent. of the sleeping accommodation should be in the special nursing section. . . . It is undesirable that any special pavilion or section should be used exclusively for patients with advanced disease (lest they should be discouraged). The pavilion or section used for these patients should also include accommodation in separate rooms for patients in other stages of the disease who require special nursing, rest in bed or supervision.

Special provision will be necessary for the destruction of sputum and for the cleansing of sputum cups.

If desired the tubercle bacilli embedded in the sputum can be killed by the addition of an alkaline lysol disinfectant; one hundred c.c. of a 5 per cent. dilution of a solution containing 4 per cent. alkali and 65 per cent. creasote when added to 50 c.c. of sputum destroys tubercle bacilli within four hours, or if the mixture be heated, within half an hour.[1] The sputum cups are emptied into an enamelled pail, the contents of which can with safety be poured down a water-closet or into a closed-in furnace. The cups are rinsed out, placed in water in a suitable vessel, such as a fish-kettle, which is brought to the boil for 5 minutes at least. Washing soda may with advantage be added to the water if the vessel is not made of aluminium. When there are a large number of cups to be dealt with, special apparatus such as steam sterilisers should be used or boilers into and from which shelved carriers may be lowered or raised.

D. FORBES.

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[1] See "Tubercle," January, 1923, p. 177.

CHAPTER VII

TUBERCULOSIS

UNDER the name of phthisis, tuberculosis was known to Hippocrates (460–377 B.C.) who described the malady and originated the term "phthisical diathesis." Celsus (30 B.C.) and Galen (A.D. 131–200) also described the disease. There is, also, evidence that it was not merely in existence, but rife at a far more remote period. Hartley and Powell, in their "Diseases of the Lungs and Pleuræ," 1921, p. xxix, state that two graves containing tuberculous skeletons dating about 2500 B.C. are described by Elliot Smith and Derry, while Elliot Smith and Ruffer describe Pott's curvature in a mummy of the 21st Dynasty, about 1000 B.C., and they state that Derry has found a series of similar specimens belonging to the period 3000 B.C. or even earlier. A similar case is described by Wood Jones. In the Nubian collection of bones in the Museum of the College of Surgeons are two specimens presenting all the characters of tuberculous disease of the spine, dates about 3000 B.C. and 2000 B.C.

That the disease was communicable seems to have been held by Isocrates, a contemporary of Hippocrates, and subsequently by Aristotle and Galen and by great physicians from time to time, but it is easy to see that this idea could not have been held with great firmness or clearness, since we know that many attacks originate tens of years before the disease appears in its full strength, a fact which not only obscures the occurrence of infection but may even confuse the order of infector and infectee. Moreover a diathesis which tends to cause the deposit of morbid materials from the blood in different parts of the body would operate in a manner so similar to an infecting agent that it would be difficult for a reflecting mind to choose between one conception and the other. Nevertheless the doctrine of the contagiousness of phthisis took firm hold in the seventeenth and eighteenth centuries. Thus Morgagni (1682–1772) expressed his dislike to the dissection of the bodies of tuberculous persons, and his fear of infection. Morton in England also regarded the disease as communicable, and so general was this belief that in France, Spain and Italy extreme public measures were taken to destroy the infection on the death of a consumptive person, or even during his lifetime. Quite probably the hardships thus entailed helped to sway the public opinion of physicians in the direction of a non-infective diathesis, though as Villemin points out there were still many scattered medical men who adhered to the doctrine of contagion. The ground was gradually prepared by exact anatomical observation. Sylvius (1614–72) pointed out the occurrence of tubercles in the lung; Magnetus (1700) described miliary tubercle. Baillie made a distinction between the disease of the lungs in which miliary nodules are a prominent feature and diffuse caseous pneumonia. Bayle (1774–1816) studied the development of the miliary tubercle, and finding that it was the same in various processes throughout the body, drew the conclusion that phthisis is due to a diathesis; he classified the disease into a variety of forms from their anatomical features. Laennec (1781–1826) in his great work, arrived at the conclusion that all these manifestations of the disease were essentially one—and are initiated by isolated miliary tubercles, which undergo multiplication, aggregation and enlargement, and produce further degenerative changes. In 1857 Buhl discovered that miliary tubercles are due to pre-existing cheesy foci. In 1862–4 appeared Hirsch's monumental work on geographical historical pathology. In the chapter dealing with pulmonary consumption are collected data in connection with the mortality-rates from consumption all over the world.

Hirsch, reviewing the facts, finds that the mortality increases with density of population, and is higher in the town than in the country.

Sedentary occupations and confinement raise the death-rate, as is well shown by the history of household troops both in England and France, by the history of religious houses and prisons, and in particular in Baly's narrative of what occurred in the Millbank Penitentiary. The same thing, an increased death-rate, is noted in occupants of common lodging-houses. Nevertheless Hirsch arrives at the conclusion that individual predisposition is the decisive factor, which may be congenital or may be called forth by noxious conditions.

It is a singular testimony to the inability of statistics to settle these questions that the same set of facts which led Hirsch to the conclusion that "contagious transmission of phthisis plays but a secondary part in the spread of the malady," should have supplied materials for the philosophical and brilliant study of the distribution of tuberculosis which led Villemin [1] to the conclusion that alike in bovines and man, the disease is spread by contagion, and that the determining factor is aggregation in both cases. He was ready to subscribe to the potency of heredity with Karl Pearson; regarding the transmitted defect as a weakness of the whole physical structure liable, however, to be replaced by the effects of environment, or by other determining factors. But he was led to this conclusion not only as the result of his etiological conspectus and observations, but proved his conclusion by a series of admirably planned inoculation experiments. His method was to inoculate with all possible care against contamination, mostly into rabbits at the root of the ear, tuberculous matter chiefly derived from the bodies of persons who had died of tuberculosis. The results were controlled in a number of experiments by uninoculated rabbits of the same litter placed along with the experimental rabbits, and the former were invariably found free from tuberculosis. In order to ensure infection in many cases he gave two or three inoculations of tuberculous material. In nearly all his experiments the inoculated rabbits became infected to a greater or less extent. He observed, however, that material inoculated from man gave rise to a less rapidly spreading and usually milder infection than was found in the single instance in which he employed bovine tuberculous material.

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[1] "Études sur la tuberculose," 1868.

Villemin made other inoculation experiments. Thus he inoculated with tuberculous matter of human origin, guinea-pigs, which became generally and rapidly infected. Birds he found entirely refractory, and concluded that they are not liable to human tuberculosis. He was also unable to produce tuberculosis by injection of human tuberculous matter into fowls and goats. The results with dogs were various though not entirely negative, but the liability of dogs to parasitic affections prescribed caution in drawing conclusions. In one out of three cats inoculated, a positive result of slight character was obtained.

He came to the conclusion that bovine tuberculosis is identical with human, notwithstanding the anatomical differences, and the different effects on the rabbit. In this view he was supported by Chauveau, who made many ingenious experiments to show the communicability of bovine tuberculosis to bovines by ingestion of tuberculous material and went far towards proving Villemin's contention that the infectious element is particulate, and of the same character as the infectious matter producing other infectious diseases. But the Académie de Médicine did not endorse Villemin's conclusions, nor was either experimenter's result generally accepted at the time, though no doubt they hastened the more complete discovery and elucidation of the disease by Koch in 1882.

The most characteristic features of bovine tuberculosis are the tendency to the formation in the lungs of pearl nodules and hard cheesy masses, the formation of villi on the pleural and peritoneal surfaces, the tendency to the formation of intestinal ulcers, large cheesy masses in the mesenteric glands and omentum, and in cows tuberculous disease of the uterus. There is thus not infrequently discharge of infection from the nostrils, the bowels, and the uterus.[1]

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[1] Prior to 1901 the close relationship, if not identity, of human and bovine tubercle bacilli, was an accepted fact, and hence the common occurrence of the bovine disease raised a strong presumption that much human tuberculosis

In equine tuberculosis there is a tendency to the formation of enormous solid masses in the mesenteric and bronchial glands. There may also be large masses in the spleen or liver; the lung may be studded with tubercles of various sizes. Tubercle bacilli may be present in enormous numbers. Giant cells are a conspicuous feature. Tuberculosis is not altogether a rare disease in the horse.

Pigs are liable to tuberculosis in varying proportions in different countries and more particularly when kept on dairy farms in connection with the dairying industry. They suffer from tuberculous lesions in the tonsils and œsophagus with consequent enlargement of the subsidiary glands, and generalised tuberculosis is common; they are also liable to contract caseous pneumonia. The chief source of infection is probably tuberculous milk, but they are also susceptible of avian and human tuberculosis. The number of pigs affected with tuberculosis may be taken as from 1 to 5 per cent.

Among other animals which suffer from natural tuberculosis are goats; but the disease is rare, less than 1 per cent. Sheep are practically immune. Dogs not infrequently suffer; the lungs are commonly affected and may present tuberculous nodules or caseous pneumonia, and even cavities. The mesenteric glands, the liver and the kidneys are liable to attack, and the animal may succumb to generalised tuberculosis. Cats frequently suffer, both from lung disease and from abdominal affections.

Birds are subject to a form of tuberculosis which may be very infectious. Avian tuberculosis is marked by the presence of very hard caseous nodules of various sizes. The parts most commonly affected are the liver, the spleen, the intestinal walls and less frequently the lungs; not infrequently the marrow of the long bones is attacked. Wild birds are rarely attacked.

Much use has been made of the rabbit and guinea-pig in elucidating the behaviour of tuberculosis. In these animals the disease runs a rapid course, and there is consequently little danger of the intrusion of lesions arising from other than experimental sources.

Since Koch's discovery of the tubercle bacillus a number of other acid-fast bacilli have been discovered, amongst others the so-called "fish bacillus," and it has been maintained that the human bacillus has been changed into this form. But this apparent change may be dismissed as a substitution. On the other hand, Nocard was of the opinion that by the transplantation of human or bovine bacilli contained in collodion capsules, from fowl to fowl, he had succeeded in changing them into avian bacilli, while Delépine exhibited a series of specimens showing progressive changes in the character of the lesions produced in guinea-pigs by inoculating these animals in series with

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was derived from the cow. The generally accepted view, nowadays, is that, while a comparatively small percentage of cases of tuberculosis in children are probably so derived, in only very few cases in adults is it possible to demonstrate the presence of bovine tubercle bacilli. It is estimated that bovine tuberculosis is responsible for some 3,000 deaths a year in this country (6·44 per cent. of all deaths from tuberculosis in England and Wales).

avian tubercle bacilli. Cobbett maintains that the battle must be fought out on the closely allied forms in the ox and man, and to this battle so far the investigations of the last Royal Commission have addressed themselves. At all events, the relationship is here so close that Koch tacitly assumed the identity of human and bovine tuberculosis, with a reservation, His words are: "I was not able to distinguish any difference in the effects produced by inoculation with material derived from varieties of the tuberculous process in man, and from the forms of animal tuberculosis." "Even were it found as a result of further research that human and bovine tubercle bacilli belonged to different species, the presence of tuberculous infection in bovines, especially in relation to milk, could not be regarded as negligible." Such was the position when the English Royal Commission of 1890 was appointed, except that meanwhile Koch in 1890 announced the discovery of tuberculin, a substance derived from glycerine bouillon in which human (or bovine) bacilli had been grown, the bacilli being killed by heat, and the medium evaporated down to about a tenth of its bulk. This material it was hoped would, when inoculated, produce a curative reaction. According to Cornet it was recognised that it possessed a solvent action on the caseous products of disease, and it was hoped that these would be expelled carrying with them the bacilli. Tuberculin received an extensive trial as a curative agent. But there could be no doubt that it did not injure the bacilli, and was, on the contrary, liable to liberate them for further action, and to lead to their dispersion both locally and in the system. Since then many modifications of tuberculin have been devised, but it cannot be said that success in this direction has been great. On the other hand, prophylactic success has been reached in cattle by inoculation of human bacilli, though not without other dangers resulting. While, however, tuberculin as a curative agent even in minimal doses, has not been a signal success, as a diagnostic material it has been of the utmost value.

THE THREE ROYAL COMMISSIONS ON TUBERCULOSIS

This Commission was appointed in the year 1890, and reported in 1895. The reference was to inquire and report on the effect, if any, of food derived from tuberculous animals on human health, and, if prejudicial, the circumstances and conditions with regard to the tuberculoses in the animal which produce that effect upon man.

Evidence was taken from a number of distinguished witnesses, but it was not of the character that the Commission wanted. More particularly no evidence was forthcoming that the lesions observed in man were of animal origin. Klein drew attention to the very different reactions of rabbits to bovine and human tuberculosis. Klein and Dreschfeld also were strongly of opinion that tuberculosis was inherited, although generally not showing gross lesions at birth. Three special inquirers were consulted—Prof. McFadyean, Dr. Sydney Martin and Dr. Sims Woodhead.

McFadyean, although of opinion that tuberculin was the most valuable diagnostic means available, expressed his disappointment as to the results obtained from its use; this unfavourable opinion he subsequently modified.

Martin examined "meat substance" derived from 21 cows, "butcher's joints," as distinct from organs, (1) microscopically, (2) by feeding with suspected matter, (3) by inoculation. Applying these tests he could not get visible evidence of the presence of tubercle except in two instances. Dividing the cows into those suffering from mild, those from moderate tuberculosis, and those from generalised tuberculosis, the cows in which the meat gave microscopic evidence were among those suffering from moderate tuberculosis. The meat of eight cows with mild tuberculosis gave one positive result from inoculation and none by feeding; that of eight with moderate tuberculosis gave three positive results from inoculation, none from feeding, and in the case of the meat of five with generalised tuberculosis, four gave positive results either by inoculation or feeding, one only out of the four appearing to answer both tests. This result is not greatly to be wondered at, since obvious tuberculous material was avoided. However, he concluded from the irregularity of the results that some other factors than disease were operative, and bethought himself that the "meat substance" might have been contaminated by slaughterer's or butcher's knives used for other tuberculous material, and in fact the material had not been carefully collected or submitted to surface sterilisation. The results, therefore, could not be depended upon. Martin called attention to the general contamination of all butcher's meat which might thus arise, and to the danger of the contamination of the meat from which tuberculous matter had been removed.

Danger from Milk—Milk was submitted from 17 cows, of which 15 were afterwards proved to be suffering from tuberculosis. Two had udder disease, proved after slaughter not to be tuberculous, and five had udder disease proved after slaughter to be tuberculous. Applying to the milk furnished by the 17 cows, the above tests, Martin found :—

(*a*) No tubercle bacilli in the milk from eight healthy udders.

(*b*) None in the milk from the two udders proved not to be tuberculous.

(*c*) Of five tuberculous cows which had udder disease found post-mortem to be of tuberculous nature, three showed tubercle bacilli in their milk.

With milk from these three cows 15 test animals were fed, with the result that tuberculosis was produced in all. With milk from one or other of the three cows 13 test animals were inoculated; tuberculosis was produced in all of them. The milk of the fourth cow with the tuberculous udder was used to feed ten test animals and produced tuberculosis in four of them; inoculated into six test animals all became tuberculous. The milk of the fifth cow was used to feed two animals, with no result. Yet when it was used to inoculate two other animals, both became tuberculous.

Woodhead's work was concerned with determining the effects of *cooking*. He found that during the boiling and roasting of rolled meat into which tuberculous material has been inserted, the temperature in the centre of the meat rarely reaches 60° C., and as meat is ordinarily cooked, cannot in the least be relied upon to render innocuous tuberculous matter smeared in the centre of a roll. Tuberculous milk was instantly rendered harmless when brought to the boiling-point. Heated to 80° C. for ten minutes, it was not always free from living tubercle bacilli.

The Commission did not hesitate to apply to man the results of experiments on lower animals. "We must believe—and here we find ourselves agreeing with the majority of those who gave evidence—that any person who takes tuberculous matter into the body as food incurs some risk of acquiring tuberculous disease. By tuberculous matter we mean here that which is capable of giving rise to tuberculosis in lower animals." They referred to the fact that Martin had found that plainly tuberculous matter produced tuberculosis in test animals by feeding in a very high proportion of instances.

In the year 1896 a Royal Commission was appointed to inquire and report "What administrative procedures are available and would be desirable for controlling the danger to man through the use of the meat and milk of tuberculous animals: and what are the considerations which should govern the action of the responsible authorities in condemning for the purposes of food supplies, animals, carcasses, or meat exhibiting any stage of tuberculosis." The report of this Commission was issued in 1898.

Evidence was obtained relating to (*a*) the prevalence of tuberculosis among dairy stock and cattle, and certain other animals destined for food, in the United Kingdom; (*b*) the sanitary conditions under which such animals are kept; (*c*) the various practices governing the inspection of meat and the control of milk offered for sale, the method under which and the extent to which these are adopted in various districts; and (*d*) the alteration in the existing laws, or their administration, advocated by the representatives of various interests affected.

The Commission reaffirmed the conclusion of the previous one that "Any person who takes tuberculous matter into the body as food incurs risk of acquiring tuberculous disease."

Full statistics as to human mortality from tuberculosis were presented by Tatham. The weak elements in these were recognised, and the conclusion drawn that "no really accurate account and trustworthy statistical data are available as to the influence of the meat or milk of tuberculous animals when used as food for adults and infants and young children respectively." Nevertheless the great reduction in the death-rate from tuberculosis at certain ages, which has occurred in spite of the increasing consumption of meat per head of population, tends to minimise the risk incurred from consumption of meat.

As to the use of tuberculin for diagnostic purposes, McFadyean stated that with certain precautions taken, he now "had the most implicit faith in tuberculin as a test for tuberculosis."

As to the prevalency of tuberculosis among cattle and swine, no satisfactory evidence was procurable so far as this country was concerned owing to the fact that no records had been kept of the total number slaughtered. Recourse was therefore had to the return of animals slaughtered in Leipzig in 1895. The proportions found affected with tuberculosis were: oxen, 28·14 per cent.; heifers, 20·35 per cent.; cows, 43·51 per cent.; bulls, 23·83 per cent.; swine, 2·73 per cent.; sheep and horses very small. Further inquiries showed that as regards swine the proportion varies enormously. Thus in Copenhagen over 15 per cent. were affected, and in Ireland it was said to exceed the proportion amongst cattle. In the Report instances are given of the hereditary transmission of tuberculosis in calves, a phenomenon known to be very rare so far as gross lesions are concerned.

A recapitulation of the legal provisions in force in connection with the *inspection of meat* is given. In practice only a small proportion were condemned on the order of a Justice. The great majority were "surrendered." The Commission found "a total absence of uniformity in the special qualifications of meat-inspectors" employed by sanitary authorities, although in some places special attention had been given to this point. As to the amount and distribution of tubercular disease which justifies the seizure and condemnation of a carcass as unfit for human food, the widest discrepancy prevailed in opinion and practice.

Nevertheless the Commission was of the opinion that the knowledge then existing was sufficient to enable the basis of a common action to be laid down. They referred also with approval to the German institution of the Freibank, though no body has yet ventured to adopt it openly in this country. They called attention to the injustice of accepting foreign meat in this country without examination of the offal, and without a certificate; also to the Public Health Scotland Act, 1897, which requires that in any proceeding with regard to a living animal, a qualified veterinary surgeon must take part, and a veterinary surgeon may act as meat inspector. The Commission with three exceptions were of opinion that compensation should not be given in respect of condemned carcasses, unless in cases in which a mistake had been committed, and that the losses incurred are best covered by a system of mutual insurance.

With reference to the milk supply, the Commission endorses the conclusion reached by their predecessor that "No doubt the largest part of the tuberculosis which man obtains through his food is by means of milk containing tuberculous matter," and they are also of opinion that, for practical purposes, the danger resides in the milk derived from tuberculous udders. By far the greatest incidence on cattle is on dairy cows, partly because they are more crowded, and less in the open, than other stock.

In Glasgow at this period, under a local Police Act, the Police Commissioners had power to inspect all cows kept for supplying milk within their jurisdiction, and to proceed against the owner if he retained any cow which "suffers from tuberculosis or any disease which might render the use of such milk dangerous or injurious to health." The Commission advised the (1) systematic inspection of the cows in dairies and cowsheds by the officers of local Sanitary Authorities; (2) that powers, similar to those enjoyed by Glasgow, shall be given when desired to cities; (3) that power shall be given to a Medical Officer of Health to suspend the milk supply from a suspected cow for a limited period, pending veterinary inspection; (4) that power be given to a Medical Officer of Health to prohibit the sale of milk from a cow certified by a veterinary surgeon to be suffering from disease of the udder which renders the animal unfit to supply milk or exhibiting clinical symptoms of tuberculosis; (5) the provision of a penalty for supplying milk for sale from any cow having obvious udder disease, unless such disease is certified by a veterinary surgeon not to be tubercular.

Elimination of Bovine Tuberculosis—A visit was paid to Denmark, and the Commissioners were shown two farms on which Bang was conducting an experiment for eliminating tuberculosis from the herd. His method consisted in erecting a movable partition in the main cowshed, retaining on one side all non-reacting cows, and such calves as did not react to the test, the number of these gradually increasing, until the reacting cows were displaced altogether. Experience shows that a herd once free from tuberculosis is only kept free by unremitting vigilance, and it is doubtful whether sufficient attention was given to the conveyance of tuberculosis by the feet, etc., from the reacting side, and whether the danger from an infected manure-stead or infected roads was adequately guarded against, also whether the sound side was kept free from infection by sufficiently rigorous or frequent disinfection.

The Commission made recommendations with regard to the qualifications of meat inspectors and the inspection of meat which have virtually been enacted ; the recommendations as to slaughter-houses, which should be consulted, have not yet been given the force of law.

In connection with milk, the Commission recommended (1) the notification, under penalty, of diseases of the udder of cows ; (2) that powers similar to those enjoyed by Glasgow should be conferred on Local Authorities ; (3) that powers be given to Local Authorities to take samples and make analysis of milks sold in the district. Recommendations were made as to the conditions which cowsheds should fulfil. In sparsely populated places a lesser cubic space may be accepted, consistently with reasonable ventilation without draught. Where cows housed in one district supply milk to another, the latter shall be bound, on request, to supply full information and veterinary reports regarding the condition of the cows, byres, etc., whence the milk is drawn, and the authority requesting a report, if dissatisfied, shall have the right to appeal to the Local Government Board.

To promote the elimination of bovine tuberculosis stockowners were to be encouraged to test their animals by the offer of a gratuitous supply of tuberculin and the gratuitous services of a veterinary surgeon on certain conditions.

(*a*) That the test be applied by a veterinary surgeon.

(*b*) That tuberculin be supplied only to such owners as will undertake to isolate healthy cows from reacting animals.

(*c*) That the stock to be tested shall be kept under satisfactory sanitary conditions, and more especially that sufficient air space, ventilation, and light be provided in the buildings occupied by the animals.

These recommendations were conceived in a broad and practical spirit, but have taken a long time before resulting in practical action.

It is true a number of local authorities fortified by experiments, observations and administrative procedures which they had engaged in, applied to Parliament in 1899, but from one cause or another, the powers which they obtained fell far short of those which the Commission recommended that they should receive. They were not able to obtain powers for dealing with cows suffering from manifest clinical tuberculosis, nor with milk of cows suffering from all forms of dangerous udder disease. They did, however, obtain with the assistance of the Local Government Board, powers for dealing with tuberculosis of the udder, known afterwards as the Model Milk Clauses. Under these powers the Local Authority were empowered to take samples of milk within their district, when a sample of mixed milk taken within their district proved to contain the infective matter of tuberculosis, and inspect the cows on the dairy farm producing the milk, the Medical

Officer of Health, or his representative, being accompanied by an authorised veterinary surgeon who might take a sample from any cow presenting signs of tuberculosis of the udder. Should such a sample on analysis by a bacteriologist, prove to contain the infection of tuberculosis, the cow affected must be isolated from the rest of the herd, and the milk must not be sold for human consumption, nor given to other animals without being boiled. The Authority in whose district the mixed milk had been delivered for the purpose of sale, might, under these clauses, suspend delivery of the whole of the milk in that district, until it was proved that the source of infection no longer existed in the herd. But for evident reasons this power was but little exercised, and in the case of individual cows, it was found possible to get the cow slaughtered, the more so that the animal was generally in a condition of advanced disease. There was, however, much evasion. Nevertheless, much good was effected under the clauses, in the earlier detection of tuberculosis of the udder, in improvement of the conditions under which cows were kept, and in more judicious selection and management of dairy stock.

Under the Milk and Dairies Act, 1915, when it comes into operation in 1925, these powers will be transferred to County Authorities, who will not go outside their district. Provision is made for co-operation between the authority in whose area the milk is produced, and the authority in whose area it is sold.

The Dairies, Cowsheds and Milkshops Order, 1899, contained the following new clause relating to tuberculosis: If at any time disease of the udder certified by a veterinary surgeon to be tubercular, exist among cattle in a dairy or cowshed or other building or place, the milk of a diseased cow therein (*a*) shall not be mixed with other milk; (*b*) shall not be used or sold for human food; (*c*) shall not be sold or used for food of swine or other animals unless and until it has been boiled.

In the absence of machinery for ascertaining the existence of such udders, we may assume that this has been a dead letter. On the other hand, the recommendations in respect of cowsheds with regard to construction, area, and cubic space, have no doubt been largely incorporated in local regulations. So far as tuberculosis is concerned the most essential conditions have been no doubt: (1) the provision and maintenance of impervious surfaces so constructed and designed as to be easily cleaned and disinfected; (2) provision of adequate ventilation, so designed as to avoid draughts; (3) good lighting, such that the windows should be in front of the cows, and in addition to any fixed openings, be opened wide in summer; (4) all parts liable to contamination should admit of frequent wet cleansing and ventilation and no food should be exposed to risk of contamination; (5) the manure shed should be at some distance from the cowshed and be so situated and constructed that the attendants on the cows shall not be liable to carry infection, nor the cows be exposed to blown infection.

But it is well that the difficulty should be realised from the first. As regards the elimination of tuberculosis from herds, Bang's experience shows how rapidly a herd of dairy cows which had been freed from tuberculosis, may become infected. Still, excellent work has been done in maintaining herds free from the disease, particularly in Birmingham, and to a less extent in Manchester.

Possibly under the grading of milk scheme a gradual progress may be achieved. The amount of effort spent on this essentially economical and wise purpose is immense, and it may prove not to have been in vain. Of this we may be sure, that progressive success will entail a long process of selection by owners of herds, and on their part intelligence, patience, and determination.

The Milk and Dairies (Consolidation) Act, 1915, provides, as has been seen, for the administration of clauses equivalent to those contained in the Model Clauses by all sanitary authorities within their own areas. It is to be hoped, however, that this is looked upon as only an imperfect step to larger things, for example to the establishment of a State Veterinary Service, and ultimately to eradication of tuberculosis from cattle. Although it may be that the danger of contraction of tuberculosis from milk is avoided by raising it to 212° F., or by pasteurisation sufficiently prolonged at 145° F., or by converting milk into dried milk, it is to be hoped that these expedients will not be allowed to displace eradication in herds. Apart from the great benefit which would thus become conferred on agriculture, it has to be admitted that notwithstanding the magnificent work of our last Royal Commission, the relations of animal to human tuberculosis are not conclusively settled, and that there are possibilities of mutual communication which pasteurisation or sterilisation of milk will evade, and which ought to be pursued.

The provisions for the grading of milk into Certified Grade A (tuberculin tested), Grade A and " pasteurised " are contained in the Milk " Special Designations " Order, 1923, dated May 25, 1923, made by the Minister of Health under Section 3 of the Milk and Dairies (Amendment) Act, 1922, which came into force on July 1, 1923.

Section 5 of the Act prescribes severe penalties on anyone selling milk of a cow suffering from tuberculosis of the udder, if he knows, or could by the exercise of reasonable care have ascertained that the cow was suffering from that disease.

No doubt much more rapid progress would have been made in respect of the recommendations of the Royal Commission, 1898, had not Koch announced at the International Congress on Tuberculosis, held in London in the year 1901, that from experiments which he had made, he had come to the conclusion that human tuberculosis cannot be conveyed to the bovine, and inferred reciprocally that bovine infection cannot be conveyed to man. Now the conclusions arrived at by the English Royal Commission were not merely derived from Koch's original labours on tuberculosis, and the opinions which he had then formed, but were founded on numerous observations indicating the conveyance to man of bovine infection. His announcement was, therefore, not accepted as 'une chose jugée,' the more so that it was logically a *non sequitur*. But it recalled directly the point emphasized by the Commission of 1894, that they had no satisfactory proof that the infection observed on the consumption of tuberculosis matter by animals was in man really due to such matter. The want then felt now demanded satisfaction, since Koch's announcement was calculated to hold up and render futile the recommendations of the Royal Commission of 1898, which were in fact partly already in operation.

A third Royal Commission was therefore appointed. Their final verdict was that human and bovine bacilli are distinct varieties, with very constant characters, and that while human tuberculosis is generally not communicable to bovines, it is communicable in a certain proportion of instances. But, in such cases, the bacilli conveyed from man are definitely of the bovine type. It followed that bovine tuberculosis in these instances had been conveyed to man either direct from a bovine animal or from another person or animal suffering from bovine tuberculosis. Generally, however, in such cases there was evidence that the disease had been conveyed to man by the bowel, and the presumption was that it had been conveyed by means of bovine tuberculous matter, most probably milk. The investigations of this Commission extended from 1901 to 1910, and are embodied in the three preliminary reports issued in 1904, 1907 and 1909 respectively, and in a final report issued in 1911, as well as in a series of supplementary reports under the signature of the investigators.

The first preliminary report, issued in 1904, consisted of an announcement that 7 out of 20 strains of tubercle bacilli obtained from human beings introduced into cattle gave rise at once to acute tuberculosis, similar to that produced by several different strains of tuberculous material of bovine origin.

The reference to the Commission was to inquire and report with respect to tuberculosis:

(1) Whether the disease in animals and man is one and the same.

(2) Whether animals and man can be reciprocally infected with it.

(3) Under what conditions, if at all, the transmission of the disease from animals to man takes place, and what are the circumstances favourable or unfavourable to such transmissions.

The first report, therefore, only answered the question whether the disease could be transmitted from man to animals and inferentially announced that it could be transferred from animals to man. A further answer to the questions put is contained in subsequent reports. The second interim report, published in 1907, covers the whole ground so far as was at that time possible.

To determine whether the disease is the same in man and the bovine it is necessary to consider what pathological effects are produced by human and bovine materials and cultures introduced artificially in live conditions into the ox and what are the morphological and cultural or other characters of the bacilli derived from the two sources. The effects of tuberculous materials of bovine origin are first discussed, these number 30 bovine strains. The materials were introduced chiefly by subcutaneous inoculation, by feeding in special cases, also intravenously and into the udder. The animals employed were Jersey calves, determined to be free from tuberculosis by the recent application of the tuberculin test. Various doses of culture were used from 50 mg. downwards. In all cases 50 mg. estimated to contain from 240,000 to 250,000 million bacilli inoculated subcutaneously, caused fatal general progressive tuberculosis. With a dose of 10 mg., variations in the result began to be manifest. The disease produced with smaller doses, varied from a fatal progressive to a limited retrogressive tuberculosis, and was shown to depend partly on the dose, partly on the powers of resistance in different animals. The first result of inoculation of 50 mg. (in the neck) was the production of a caseous tuberculous mass, infiltrating the adjoining tissues, followed by invasion of the prescapular and lymphatic glands, also changed into a caseous mass, then by invasion and caseation of the bronchial and mediastinal glands, with subsequent extension to the various organs. After about 12 days the animal began to be ill, with rise of temperature, and death occurred in from 28 to 50 days.

The bacilli were introduced either as cultures or as emulsions of tuberculous material. It was found that as emulsions they exerted a much more potent effect than as cultures, fatal progressive tuberculosis being produced by emulsions estimated to contain not more than ·01 mg. of tubercle bacilli. By the introduction of tuberculous material into the intramammary ducts, tuberculosis of the udder is produced which may remain confined to the quarters injected, may give rise to death without extension of the process, may spread to adjoining quarters, or may produce generalised tuberculosis. Of six calves fed with milk from tuberculous udders so produced, over prolonged periods, only one became affected with progressive fatal tuberculosis, the lesions in the others being limited and confined to the abdominal organs. It is thus much more difficult to convey tuberculosis by feeding than by other methods.

Guinea-pigs are extremely susceptible even to very small doses introduced by inoculation and readily become affected with generalised tuberculosis by feeding, yet not so certainly.

Rabbits—Inoculations of even small doses always produced fatal generalised tuberculosis; feeding, not so readily as in the guinea-pig.

Pigs—By inoculation generalised progressive tuberculosis may readily be set up, even by small doses; by feeding this was also the case.

Monkeys—Inoculation produced fatal generalised tuberculosis, in one case with a dose of not more than ·001 mg. Feeding with 1 mg. of culture readily produced fatal generalised tuberculosis in baboons.

Anthropoid Apes—Inoculation with 1 mg. of culture produced fatal generalised tuberculosis. Feeding with comparatively small doses, 1 mg. or less, also produced fatal generalised tuberculosis.

Human Tuberculosis—Up to the issue of this report, the human tuberculous materials used were derived from 60 cases. The results obtained by introduction of viruses from these materials divide themselves into three groups.

Group I numbered 14, obtained in one instance from mixed sputum feeding, in 3 from tuberculous cervical glands, and in 10 from the lesions of cases of primary abdominal tuberculosis.

In these the effects of the introduction of emulsions or cultures presented the same characters as regards variations in virulence, and the production of fatal generalised progressive tuberculosis in calves, when inoculated subcutaneously in doses of 50 mg. of culture, as did the tuberculous materials from bovine animals. In rabbits, also, like the bovine materials, these produced a fatal generalised tuberculosis, even in very small doses, and the results with pigs, goats, monkeys, a dog, and a chimpanzee were similar.

Group II was made up of 40 cases of very different kinds, cervical glands, 8 mesenteric glands removed after death primarily affected, 10 lungs or bronchial glands apparently of respiratory origin, tuberculous kidney, and 1 tuberculous testis, 9 cases of infections of the joints or bones. When an emulsion was inoculated a local lesion was produced, more or less markedly retrogressive, not infiltrating, and circumscribed by a zone of fibrous tissue. More or less tuberculous deposits, distinctly retrogressive, occurred in the nearest lymphatic glands, which might even be absent, as might the tuberculous deposit at the site of inoculation. A few minute scattered nodules in other organs might be present.

Inoculation of 50 mg. of culture produced very definite effects. In all cases the lesions were circumscribed and non-progressive, though a few scattered tuberculous nodules might be found in distant organs. Much larger doses also failed to produce severe disease. In rabbits intraperitoneal inoculation of even 50 mg. of culture failed to produce a fatal tuberculosis. In guinea-pigs the tuberculosis produced was apparently as severe as when tuberculous material from bovines was used. In pigs and goats tuberculous material from this group was apparently unable to produce tuberculosis. In monkeys and anthropoid apes, the affection produced was similar to that obtained with bovine material.

The effects of the subcutaneous inoculation of emulsions and cultures of bacilli from tuberculous material from Group II of human cases, differed widely from those produced by emulsion and cultures derived from tuberculous material from bovines and from the human material of Group I, both in their effects on calves and on rabbits, pigs and goats. The results of feeding calves with individual human sputum were in the first instance not widely different from those produced by feeding calves with bovine material, though the lesions produced in the latter case were generally limited, and it was manifest that feeding produced tuberculosis with difficulty, as compared with inoculation. But the results of inoculation with materials derived from these initial lesions were widely different. In the case of two samples of mixed sputum fed to calves over prolonged periods, the lesions produced were at first apparently limited and retrogressive, but the results of passage experiments with these lesions were different and irregular, leading to the ultimate production of fatal progressive tuberculosis in the calf and to anomalies in the cultures derived from the lesions.

Eastwood's investigations showed that the initial tubercles produced whether of human or bovine origin, showed no anatomical, histological or physiological differences. In no mammal was the disease produced by material of human origin more severe than that produced by material of bovine origin. The differences in human and bovine tubercle bacilli appeared therefore to be more in the nature of difference of virulence than of character.

Cultures—The materials obtained from human and bovine sources were studied by the production of cultures on a variety of media: blood serum (derived from various animals), glycerin serum, glycerin broth, glycerin agar and glycerin potato, and were investigated by Cobbett for human materials, by A. S. Griffith for bovine materials, and by Eastwood for both. Eastwood rested his classification on the examination of cultures obtained from a variety of media, the other two observers chiefly on those from glycerin serum. The agreement in their conclusions was very close. Eastwood classified his cultures into five groups, according as they grew with more or less difficulty on his various media, dividing them into three groups, according as grew with more difficulty (Grades I, II, III, of dysgonic cultures), or less, Grade IV and V, of eugonic. It was found that all the cultures of bovine origin fell into the three Grades I, II and III, all of those of human character into IV and V. Eastwood insists that, arranged in series of dysgonic growth, there is no clear line of division as regards the appearance of the culture such as exists in respect of virulence.

The differences in easiness of culture within these divisions corresponded to no virulence on inoculation, nor was the instability in culture accompanied by any alteration in virulence. The bacilli of human and bovine origin show great differences in length when growing freely in the tissues. In cultures they are short straight rods. They tend to be longer in luxuriant cultures, and the human bacillus shows a greater tendency to be slightly curved than the bovine. But the differences are slight.

Besides the two main groups of human cases, those which give results identical with bovine tuberculosis Group I, numbering 14 cases, and Group II of widely differing virulence, numbering 40, a Group III was formed, characterised in one strain or another, by instability in culture but having no other connecting feature. The investigation of these cases was incomplete, and reserved for a subsequent report. Two possible explanations might be given, either that the anomalous features might be due to an admixture in the tuberculous material of human and bovine bacilli, or that in passing through the body of the calf the characters of human bacilli had been changed into those of bovine bacilli. Against this last hypothesis was the remarkable stability in virulence of the bacilli in bovine tuberculosis and Groups I and II, both in cultural characters, and in virulence, even after a long passage through animals.

The third interim report, issued in 1909, was concerned with the sources from which bovine tubercle bacilli are introduced into milk, and an investigation was carried out by Griffith on six cows, with special reference to the contamination of the milk.

The final report of the Royal Commission, issued in 1911, contains a review and a revision of the work previously reported, and also two new researches, one on lupus, the other on equine tuberculosis. The main conclusions of the previous reports are unaltered.

Section X of this report is devoted to a summary of the results obtained in terms of the reference to the Commission. The questions submitted were:

(1) Whether tuberculosis in animals and man is one and the same. In the absence of morphological distinction between bacilli of the human and bovine type, and on the basis of a study of the features of cultures, and of experiments on animals, the Commission conclude that there are not sufficient grounds to affirm the presence of a specific distinction, and that the two types of bacilli may be regarded as varieties of one and the same organism.

(2) Whether animals and man can be reciprocally infected with tuberculosis; that is, whether the disease known as tuberculosis can be communicated from man to animals, and from animals to man.

Avian tuberculosis having been excluded from consideration, it has been shown from an experimental study of the human and bovine bacillus when transmitted to animals, that tuberculosis as it occurs in man can be transmitted to bovines, while it has been shown with certainty that bovine tuberculosis has been communicated to man, though, of course, not by way of direct experiment. The conclusion is that mammals and man can be reciprocally infected, a conclusion not diminished by the fact that the majority of cases examined in which the bacillus causing the human disease was shown to be of bovine origin occurred in young children.

(3) Under what conditions, if at all, the transmission of tuberculosis from animals to man takes place and what are the circumstances favourable or unfavourable to such transmission.

The observations made on tuberculosis in the bovine and goat do not permit a confident statement that man is free from risk of infection from animals with bacilli of the human type, though such risk can hardly be great. There is also risk of infection of bovine tuberculosis with the flesh of bovines, and of both the bovine and human type of bacillus from the flesh of pigs. But both clinical and experimental evidence show that the chief danger to man is from cow's milk. Chiefly this is due to the occurrence of tuberculous disease of the udder. The results recorded in the third interim report, however, show that this danger is greatly augmented, by the transmission of tubercle bacilli, probably intermittent in character, through the uninjured udders of cows suffering from clinical tuberculosis, as well as by the secretion of bacilli in the fæces of such cows (and also from uterine discharges when the uterus is affected). There is also danger from discharges by the mouth. The conclusions of a previous Commission are thus strengthened that the removal of such cows from herds is a matter of urgency.

With a view to give effect to the conclusions of the Royal Commission, 1898, and to the results embodied in the Third Interim Report of the last Royal Commission, issued in 1909, the Board of Agriculture and Fisheries, in the year 1909 and again in 1913, issued an order under the Diseases of Animals Acts, having for its object the removal from herds of all cows suffering from tuberculous disease of the udder, and yielding tuberculous milk, and of all bovine animals appearing to be suffering from tuberculosis with emaciation. The duty of enforcing the order was placed on local authorities.

Veterinary surgeons and veterinary practitioners were required to notify the above conditions, as well as induration or other diseases of the udder, to the local authority. The local authority must thereupon cause their veterinary inspector to examine the animal notified; he might apply the tuberculin test with the consent of the owner, and might take samples of milk, fæces, and urine for examination. As soon as possible he must report to his authority on the conditions found. If he reported that a cow was suffering from tuberculosis of the udder, or was giving tuberculous milk, or that a bovine animal was suffering from tuberculosis with emaciation, the local authority must forthwith give notice in writing to the owner, and to the Board of Agriculture, and cause the animal to be slaughtered.

Provision was made for valuation of the animal during life, which took account of the certificate that the animal was suffering from tuberculosis. After slaughter the carcass was valued by a veterinary surgeon who was to be guided, if the animal was tuberculous, by the rules laid down by the Royal Commission, 1898. The ultimate compensation paid was determined both by the valuation during life, and by the valuation of the carcass. When the animal was found not to be tuberculous, full compensation on the valuation during life was to be paid, plus twenty shillings.

Provision was further made for detention and isolation of animals, and for dealing with suspected milk. A veterinary inspector might require an animal exposed in a market, fair-ground or sale-yard which appeared to him to be suffering from the notifiable conditions to be removed.

This order was in force up to the outbreak of the War, and though expensive, undoubtedly effected an improvement. Its good effects were largely destroyed by the wholesale slaughter of young cattle which occurred during the subsequent years. It may be doubted whether, even apart from such set-backs, it would have resulted in a reduction of the infection from milk corresponding to the expectations entertained of it, even supposing it to be administered strictly and without evasions, although it is difficult to see how on any other plan the indications of successive Royal Commissions could have been fulfilled. But it is doubtful whether the great infectiveness of tuberculosis has ever been sufficiently realised, and without such outlook, the improvement resulting could only have been slow and imperfect. One effect which it was capable of producing was the inception of a whole time and adequate Veterinary State Service which might be of the greatest service to the agricultural and especially to the dairy industry, and without which progress must be halting and doubtful. Were such a service established, its functions should, from the first, be directed in preventive and educational directions, in association with the clinical, but made as far as possible to predominate.

CAUSES OF TUBERCULOSIS

In Newsholme's work, "The Prevention of Tuberculosis," 1908, the various predisposing and exciting causes (lack of cleanliness, illnutrition, alcoholism, poverty, defective housing, limitation of spread by institutional segregation or other measures) inimical or contributing to the decline of tuberculosis are examined.[1]

The reliability of the statistics relating to tuberculosis is discussed by Newsholme, and he is of opinion that for the country as a whole, the figures are reliable, notwithstanding defects in registration, at all events, sufficiently so to make the main features valid.

If reference be made to the death-rate at 11 groups of ages, given in the last Decennial Supplement of the Registrar-General, for pulmonary tuberculosis, pneumonia, and bronchitis respectively in successive decennia since 1861–70, it will be seen that in the case of bronchitis there has been a tendency to a long continued descent in the death-rate parallel with that for tuberculosis, interrupted no doubt from time to time. But it is certain that the transference of deaths is most likely to take place between tuberculosis and bronchitis, and the figures, therefore, support the reality of the decline from phthisis, while not impugning the possibility of transference between one condition and the other.

In the case of pneumonia the tendency is to a steady and marked *increase* in the death-rate at those age-groups in which the fall of the tuberculous death-rate is most conspicuous. If transference has occurred, it has been alike from phthisis and bronchitis to pneumonia. Still this transference has been of a minor order, and the decline in tuberculosis at middle ages stands unaffected. But these are not the only directions in which transference has occurred in the past to a much greater extent than now prevails. All wasting diseases were subject to it, such as diabetes, cancer and various forms of malnutrition affecting more especially the earlier and later periods of life.

It cannot be doubted that the diagnosis of tuberculosis which is by no means easy in all cases, is now much more certain than it was at former periods, and that, in a historical survey, account must be taken of increasing inaccuracy as we recede from the present time.

Bulstrode refers to Niven's analysis of the principal causes which are likely to have promoted the remarkable decline in pulmonary tuberculosis in England and Wales, noting that the chief factor has been the great advance in the material well-being of the working classes, producing increased resistance to the disease. It may be added that the influence of movement of population (migration), with the consequential removal from, or introduction into, the various countries concerned, of actual or potential cases of tuberculosis, is one which must, of course, not be lost sight of in considering the decline in the phthisis death-rate in certain countries, and its stationary state or even actual increase in others.

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[1] See also "The Elements of Vital Statistics," by the same writer, p. 452.

When a diagram is constructed showing the mean annual death-rates from tuberculosis, corrected for age and sex distribution, from 1860 to 1910, it is seen that a line drawn from the top of the column for 1864 to the top of the column for 1910, very nearly passes through the top of the column for intermediate years.[1] The Registrar-General's Decennial Supplement for 1901–10 gives a table from which the decennial rates of decrease at all ages and at all groups of ages for males, females and persons may be followed up to 1910, in which the acceleration of the rates of decrease is very manifest since the decennium 1851–60. During the interval of 50 years covered by the table, tuberculosis mortality has been nearly halved in males, and far more than halved among females. The greatest reduction among males appears to have occurred at ages 10–25, and among females at ages 15–45. These reductions have therefore both socially and economically occurred at the most advantageous ages for the population.

Owing to events occurring during the Great War and to the effects of the influenza epidemic, a set-back occurred in the rate of decrease, but there is now every appearance that it will be resumed. The Registrar-General states that "the deaths assigned to tuberculous affections in the aggregate numbered in the decennium 1901–10, 565,161, being fewer by 50,845 than the number in the preceding decennium. Corrected for estimated increase of population, the difference becomes 121,941; a further consideration raises it to 128,758."

We find that during the three quinquennia 1896–1900, 1901–5 and 1906–10 in many great towns, there is a marked decline in the death-rates, most conspicuous in London, Boston, New York, Edinburgh, Glasgow, Dublin, Belfast, Hamburg, Munich, Dresden, Breslau, Amsterdam, Rotterdam, The Hague, Vienna, Prague, Christiania, Copenhagen, Moscow, Turin, though the death-rates vary greatly.

No decline, or only a small one, occurred in Chicago, Philadelphia, Paris, Budapest, Stockholm, Petrograd and Milan. Similarly, great differences are shown for different countries during the same periods. Marked decline is exhibited in the same periods in the United States, England and Wales, New Zealand, Australia, Germany, Prussia, Saxony, the Netherlands, Belgium and Denmark. It is not great in Ireland, Austria and Switzerland, while the disease was stationary or increasing in France, Spain, Italy, Norway, Serbia, Hungary and Japan. The Great War caused an increase in the combatant countries.

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[1] In his Statistical Review for 1921 the Registrar-General comments upon the "surprising constancy of the decline over so long a period as 55 years—1866–1921."

To account for these differences and changes, it would be necessary to give a separate study to the history of each individual country. But, if we consider the great amount of intercourse now existing between different nations, which, it may be hoped, will be soon further increased, it seems likely that the prevalence of tuberculosis in some countries and its recent increase, will constitute for a time a serious menace to those which are more progressive.

The great majority of all cases of tuberculosis are pulmonary. For England and Wales, in the successive decennia beginning with 1851–60, the percentage of the deaths due to tuberculosis that was caused by forms other than pulmonary was 20·3, 20·6, 25·9, 29·3, 30·6. In 1911 the percentage was 27·7 and in 1921, 21·6. The ages affected by different forms is very different, and varies greatly. It is now necessary to refer to the distribution in age-groups when a curve is constructed for the death-rates at eleven groups of ages, such as that given by Newsholme [1] for 1904, for phthisis, males and females.

Taking first the chart for males, we find that the curve begins with a low death-rate, descends to the lowest point at ages 5–9, ascends slightly at ages 10–14, and then mounts steeply till it reaches the age period 55–65, and thereafter more quickly. The curve for female mortality-rate is much more rounded though ascending rapidly from ages 5–9 to ages 15–20, at which it is above the curve for male death-rates. From the age-period 15–20 it begins to fall below the male curve, the distance quickly increasing till it reaches a maximum at ages 45–54, when the death-rate is about half that of males. The highest death-rate is reached in the age-period 35–44. The terminal distance between the two curves at ages 65 and upwards is still considerable, but less than half the maximum distance.

When the death-rates from phthisis at different groups of ages are studied throughout the six decennia, it is seen that the above characters have not been constant. In 1851–60 the death-rate from females exceeded the death-rate of females at all ages, and the present excess of the male death-rate has gradually evolved during fifty years.

In the first two decennia the female death-rates exceed the male up to the age-period 35–44. In 1871–80 the latest excess occurs at the ages 20–24, and in 1881–90 at ages 15–19, at which age-period it has remained, a great fall meanwhile occurring at all later ages in females. In recent years a tendency has appeared for the female death-rate from phthisis to approach the male death-rate. But this may be only temporary. In all the decennia the female has exceeded the male death-rate in the earlier age-periods and the male has exceeded the female death-rate at later age-periods, though with different points of crossing, and to different extents, the main feature being the great relative fall in the female death-rates throughout the years at the middle and late periods of life. There can be little doubt that this is connected with the comparative protection of women's and children's work in industrial communities. These changes are much less marked in the rural districts, for which the curves resemble those of three decennia back. Similarly, the curves for Ireland resemble those of England in 1861–70.

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[1] Newsholme, "Prevention of Tuberculosis," p. 8.

The commencement of the long continued and uniform fall in the death-rate nearly coincided with the great uprush of industrial activity and prosperity, as happened more recently in Germany. The strongest and most enterprising members of rural families were in demand, and found work both in the towns and elsewhere. These movements resulted necessarily in a great decrease in overcrowding in country districts, while at the same time food became more abundant, varied, and cheaper. But the chief benefits came to the member who went out to find employment, though the family remaining at home no doubt shared. At the same time all those interested in the industries and enterprises into which they migrated benefited, had better food and houses, as well as the tradesmen who catered for them. An important result of the stir and movement was the diminution of intermarriage in rural districts, and consequent improvement of the stock. It is true the conditions of housing and industry especially in great industrial towns were bad. But they were gradually mending, and at this period sanitary legislation and agitation were very active. Factory conditions were improving, the Public Health Acts, especially the Act of 1875, introduced many improvements. Certainly if one's view is confined to the slums of great towns, it is difficult to see where the beneficial results of industrial development came in, but it is necessary to remember that the increased prosperity flowed over all classes, especially those connected with industry and trade, and to a less extent over those remaining on the land. A considerable body of legislation was already in existence in 1860 which limited the hours of employment of women and children as well as of young persons, and incidentally of adults. Lord Shaftesbury's Commission, which extended from 1862 to 1866, surveyed the whole field of labour not as yet under the control of factory legislation, and its recommendations were embodied in the Act of 1864. This again was followed by the Factory Act of 1867, the Royal Commission of 1875, and the Factory and Workshops Act of 1878. Thus about the period when the death-rate from tuberculosis began to fall there was a great outbreak of effort directed largely to limitation of the exhaustion produced by excessive or unsuitable hours of work for women, children and young persons. It can scarcely be doubted that these legislative measures and those which had followed had much to do not only with the reduction of the death-rate from all causes, but especially with that due to tuberculosis and with the retreat to higher ages of the most fatal period of tuberculosis, as well as with the manner in which the death-rate of unprotected men from this disease, as well as from other causes, went ahead of that prevailing among women and young persons. The absence of such legislation also no doubt had to do with the manner in which these improvements in the death-rates lagged in rural districts. It is impossible here to deal with the many complex questions which are involved in the rise of industry and commerce. But it may be pointed out that in the great centres, the congestion which followed the movement from the country to the town was followed by a great increase in the provision of houses under gradually improving conditions as revealed by the Census figures for housing. It is usually assumed that in rural districts there was no such aggregation of persons as occurred in great towns with the increase of casual labour. But it may be doubted whether, relatively to the population, this was not greater in rural than urban districts, especially in the earlier decennia.

The registered figures of deaths from tuberculosis show a proportion of pulmonary to other forms of tuberculosis varying from 80 in the earlier periods to 70 per cent. in 1901–10, while in 1921 the proportion has reverted to the former figure. It is doubtful whether much importance attaches to the ratio between respiratory and other forms. The entry pulmonary tuberculosis is subject to errors even at the age at which it is easiest to diagnose, and at the earlier and later ages these must be much greater. Experimental investigation tends to show that the error is in excess at early ages, while it is probable that in advanced life it is by defect in the numbers registered. Thus the total error, however, in all likelihood is not much greater than the records reveal. But it is to other forms of tuberculosis that uncertainty chiefly attaches. There are a large number of cases such as those of bone and joint disease, renal tuberculosis, lupus, and other skin affections in which clinical error is probably small. But much doubt attaches to such forms as tuberculous meningitis and tabes mesenterica.[1] Lupus and scrofula may be disregarded, generalised tuberculosis is by far the most important. At all ages "Other forms" in the decennium 1901–10, cause a death-rate less than that due to tuberculous meningitis and greater than that due to abdominal tuberculosis. The deaths from "Other forms" when followed upwards through the 11 groups of ages, as well as those from its sub-heads, follow a descending course, as age advances, in the same manner as do tuberculous meningitis and tuberculous peritonitis, and one totally different from deaths due to the pulmonary form of the disease,

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[1] The Registrar-General in his study of tubercular meningitis shows that in all probability considerable changes have been made in certification. Again, in the first few years of life the diagnosis of abdominal tuberculosis is inextricably mixed up with that of malnutrition.

Brownlee in his Reports to the Medical Research Council has made a detailed study of the distribution of mortality at the various age-periods in England and Wales and has been led to conceive of phthisis as consisting of three types of tuberculosis with different characteristics and behaviours, each type pursuing its independent course according to an age scheme of its own. These types he names the young, middle age and old type. In our opinion the writer has not clearly proved a need for the conception of three varieties of the human type of the bacillus. Sufficient attention has not been given to the effect of migration at different ages into large towns. Also there is no bacteriological authority for such a conception.

FACTORS SUPPOSED TO FAVOUR THE OCCURRENCE OF TUBERCULOSIS

The one essential and predominant fact about tuberculosis is that it is caused by the introduction into the body of the tubercle bacillus, and its multiplication and dissemination. So much has been proved by observation and experiment. But it seems equally certain that in the majority of persons, it fails, even after establishing distinct foci, to produce the disease. Probably in most instances it fails even to gain a foothold. The evidence to the effect that extensive invasion occurs at an early age relates to sections of the community in which we should expect an unusual amount of invasion, and a minimum degree of resistance, and it is probable that the proportion of children invaded at an early age is much less in the community as a whole. It is necessary now to consider under what circumstances invasion occurs.

(1) **Race**—As we have seen, some animals are much more susceptible than others, and it has been asserted that some races of man are much more susceptible than others. There is very little evidence of this. It has been noted that native races, hitherto free from tuberculosis, like the American Indians, African tribes, and the natives of New Zealand, when their mode of life has been changed, and they have been either exposed to infection under unfavourable conditions, or cooped up in habitations, have been severely visited by tuberculosis. A similar experience was observed in the Great War amongst troops from India and Africa, subjected to conditions of climate which must have greatly depressed their powers of resistance both to attack and to extension of the disease. A like susceptibility occurs in Europeans who settle in tropical countries. Negroes in the United States have an excessive death-rate, but not more excessive than that

prevailing among those of our urban communities, who live in like insanitary conditions. How much then is due to racial differences, how much to difference in the amount of inherited resistance, and how much to unfavourable conditions of life, there is no means of telling. But everything seems to indicate that the last factor is the most powerful and the main one.

It may be observed that tuberculosis is not less rife among the oldest known races, like those inhabiting India, Egypt and Italy, than it is among nations of more recent origin, nor does Ireland's long and severe experience appear to have produced any racial immunity.

Karl Pearson, working with imperfect data, arrived at the conclusion that heredity plays a powerful part in producing the observed incidence of pulmonary tuberculosis. But the heredity which he considers to exist is one of the order of those physical and mental characters, which we see to be handed from parent to child, and constitute in that sense a predisposition. Even in this limited sense, however, heredity is open to doubt. As regards the inception of tuberculosis it is apparently contrary to the experimental evidence. It is an old observation, however, that phthisis is specially liable to be found in persons of a particular slim build with small respiratory capacity, who inherit this physical conformation. Even Villemin was not prepared to reject heredity from this point of view, though he hesitates to accept it, remarking that these defective conformations are often the consequence rather than the cause of tuberculosis, which has, perhaps, been present longer than the victim knows. It is in fact a case of taking the effect for the cause. Yet the general verdict would be, that this habit of body, when not allied with mental vigour, does predispose to phthisis, that it is to progressive invasion. Still, we find plenty of cases in which the disease has been grafted on a well-formed frame, and we cannot tell how far infection is favoured by a sedentary occupation and pursuits. Nor does a slender physique always indicate feeble powers of resistance, any more than a robust physique necessarily indicates strong powers of resistance.

The question is usually discussed as one concerning phthisical parents and phthisical children, in whom it is impossible to arrive at a conclusion how far the sequence is due to infection and how far to heredity in any sense. If children contract tuberculosis while still very young, say in one-third of the cases, we are unable to date the reception of infection. In any case it is impossible to say how many of such invasions result in serious attacks.

(2) **Climate**—It would be fair to claim a preventive action from residence at high altitudes. But the results thus obtained probably depend more on exercise and care than on immunity from attack. At still higher altitudes, *e.g.*, Potosis, Mexico, it is claimed that tuberculosis is rare. But such altitudes are unsuitable for treatment, and

their immunity from invasion may be due largely to exemption from exposure to infection. The influence of high and rain-bearing winds has received careful study from W. Gordon, who arrived at the conclusion that districts in Devonshire much exposed to such winds suffered unduly from phthisis. Brownlee, on the whole, finds himself unable to sustain this thesis, while Powell and Hartley consider that " the ill effects of winds may be in part direct, but are perhaps more largely due to the closing of doors and windows to which their violence often leads," that in fact they resolve themselves into the effects of domestic infection, aggravated by winds and wet. The causes are probably complex.

(3) **Predisposition in Males and Females Respectively**—Allusion has already been made to a probable influence of sex in causing the early excess of phthisis in females.[1]

(4) **Poverty**—With a view to ascertain if possible some of the factors concerned, Newsholme compares the curves showing the death-rates from phthisis from 1851–60 onwards, in England and Wales, Scotland and Ireland with a curve for the United Kingdom showing the price of wheat. Fairly close association for England and Wales and Scotland, coincides with disassociation in Ireland, poor association for France, and moderate association for Germany.

Fluctuations in the extent of casual labour and of wage values play their part in determining the degree of poverty, with its heritage of illness and misfortune for the children. It may be divided into remediable, where there is natural incapacity, irremediable, or at least very difficult to remedy, where there is natural incapacity. This large class drinks heavily, it may be assumed that all casual or irregular workers tend to the public-house when they are off work.

The annual report on the health of Manchester, 1910, contains an enumeration of public-houses area by area, and on comparing this with the death-rates from phthisis, it will be seen that the correspondence between the numbers of public-houses and the death-rates in sanitary districts (20 in number) is fairly close. Nor can this be taken to mean that when the population is most dense, there are most public-houses. Such correspondence does not exist. The suggestion rather is that where there are more public-houses, there is more phthisis. Apart from these figures, there can be no doubt that the indiscriminate spitting and close atmosphere of the public-house propagates phthisis.

The casual labourer has to put up with deficient house room, and is often to be found in a common lodging-house. If work is slack the house tends to get neglected and to become dirty, a harbourage for infection. If he resides in a common lodging-house or crowded tenemented house he may be exposed intimately to infection, as there are likely to be one or more in the house phthisical and expectorating.

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[1] The question of the extent to which conjugal tuberculosis occurs has been examined from time to time. Longstaff (" Studies in Statistics "), from study of mortality figures, was unable to find evidence of infection from husband to wife, or vice versa. The whole subject is considered by Bulstrode in his " Report on Sanatoria for Consumption," 1907, p. 72.

In the Annual Report for 1910 are given separate tables for death-rates from males and females showing the death-rates in groups of ages, according as death occurred at home, in poor law or in other institutions. A fair idea is thus given of the amount of poverty existing in 20 sanitary districts and of the effect on the total mortality from phthisis; it will there be seen to be most intimate, especially in those districts in which common lodging-houses are numerous. But it is necessary to remember that all prolonged fatal illnesses cause poverty. For example, such is the case for deaths from diseases of the nervous system, cancer, and other forms of lung disease. It is when we study the ages at which death occurs from tuberculosis that we realise the importance of the figures; the mortality is heavy *from the age of 25 upwards.* Poverty is here a consequence as much as a cause of disease. The illness of the husband means loss of work and earnings, infection at home, infection in the workshop, the mother obliged to leave the children neglected with the sick husband while she seeks work; poor food and poor clothing are their portion. The children usually have not yet begun to earn a livelihood. Phthisis is thus of all diseases the most impoverishing.

Great changes have taken place tending to diminish the effect of poverty in producing the spread or intensification of phthisis, or to mitigate the consequences of war. The most important of these are the notification of all forms of tuberculosis and the establishment of schemes for carrying out measures of prevention, and for the treatment of cases of pulmonary tuberculosis.

In connection with such schemes provision of aid to the families of the patients, as a preventive measure, and to the patient while resident at home, is often made. These measures have been of great assistance both for prevention and treatment. A considerable change also has come over the attitude of Boards of Guardians to the treatment of the disease. Thus a great advance has been made in the extent and quality of the assistance rendered in preventing and treating the disease, and to this must largely be ascribed the continued fall in the death-rate from tuberculosis. Advances have, moreover, been made in the knowledge of treatment. Indirectly benefit has accrued from the administration of medical benefit under the National Insurance Acts, and from administrative progress, as for example in respect of child welfare.

(5) **Drink and Tuberculosis**—The effects of drinking on tuber-

culosis are by no means confined to the share which it takes in the production of pulmonary tuberculosis. The high price of alcohol and the limiting of the hours at which drinking is permitted have no doubt diminished the danger, and perhaps these are the best weapons by which the mischief may be controlled. But further measures are called for.

(6) **Injurious Occupations**—All dusty occupations are injurious to the lungs, though their influence in producing tuberculosis varies greatly. Coal-dust, for example, is not attended with the rapid spread of tuberculosis, and it has even been held that it protects against invasion. This is unlikely, and it may be that the apparent protection is due to lesser exposure to infection and to good ventilation. Much of the phthisis due to irritating dusts in mining, in potteries and in quarrying has been shown to lead to a process of fibrosis, which often terminates by the production of tuberculosis, according to the degree of exposure of the injured lung to infection outside the occupation and to the degree and character of the irritation.[1]

(7) **Light**—It has been amply proved that direct sunlight is rapidly destructive to the tubercle bacillus, when it has access to it, and diffuse light more gradually. In this connection the work of Downes, Koch, Delépine, and Ransome may be mentioned. Dirt and dust prevent this action of light. Direct sunlight also exerts, under suitable conditions, an invigorating action on the system.

(8) **Movement of Air**—Free movement of air removes infection or dilutes it, and has a beneficial action on the system, whether by stimulation of the lungs, or by its action on the skin. Under certain conditions, however, as for example in a common lodging where infectious expectoration is trodden and converted into fine dust, this benefit may disappear. In general an out of door life is a protective against infection, and diminishes its influence.

(9) **Housing**—Successive Census enumerations have shown that the population tends to demand a lessened density per room, and this has no doubt had an influence in diminishing the death-rate from tuberculosis. The existing scarcity of houses must check this influence, although the measures now taken to limit the deposit of expectoration in rooms is a powerful agency in the opposite direction.

(10) **Aggregation**—But, in whatever manner it comes about, whether by the extension of urban communities, the clustering of villages, or the thick dotting of farms and homes over the countryside, it is, as Villemin constantly insisted, owing to aggregation that the disease spreads. That infection is no necessary consequence of

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[1] A discussion of tuberculous mortality from occupations will be found in the Decennial Supplements on occupational mortalities of the Registrar-General, and in works by various writers, Greenhow, T. Oliver, Scurfield, Wheatley, Collis, etc.

aggregation is shown by the absence of infection in well-managed schools, and sanatoria, which furnish abundant proof that with sufficient care it is possible to limit infection.

The influence of aggregation appears from figures given by Shirley Murphy in a paper read before the British Congress on Tuberculosis, 1901. The proportions of the population living more than two to a room in tenements of less than five rooms, and the corresponding phthisis death-rates in 1894–8 were:

PHTHISIS AND OVERCROWDING IN LONDON

Proportion of total population living more than two in a room (in tenements of less than five rooms).	The phthisis death-rate per 1,000 of population in 1894–8 varied from
District with under 10 per cent.	1·07 to 1·18
„ „ „ 10–15 „	1·38 „ 1·49
„ „ „ 15–20 „	1·57 „ 1·64
„ „ „ 20–25 „	1·67 „ 1·83
„ „ „ 25–30 „	2·06 „ 2·11
„ „ „ 30–35 „	2·13 „ 2·42
„ „ over 35 „	2·46 „ 2·66

Figures given by Chalmers similarly show the intimate relation between the number of rooms per house and the death-rate from phthisis. Used as illustrations these figures are useful.

The work of Koch and his followers, and particularly of Cornet, led to the adoption of measures designed to prevent spread of the disease. Thus in 1892 he pointed out that moist sputum will not permit the bacilli to escape, and that it was therefore of cardinal importance that expectorated matter should not be allowed to become dried.[1]

About the same time Ransome, through the Consumption Hospital, issued prophylactic instructions.

It is interesting to note that both Cornet and Ransome insisted that the tuberculous person, in obeying such instructions, was ensuring his own safety, since he was liable to contract fresh infection.

Attention was particularly drawn to the danger that a consumptive swallowing his sputum might infect his bowels.

In 1899 several authorities adopted schemes for the prevention of phthisis, and as a first step notification of the disease was adopted, and prophylactic investigation, instruction, and other measures were initiated in Brighton, Sheffield, and Manchester.

Existing knowledge appears to have made it manifest that the bacillus of tuberculosis found its way into the human body from two principal sources.

(1) From the consumption of unsterilised tuberculous material

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[1] The evidence as to the influences of dried sputum and of "droplet infection" respectively is considered by Bulstrode ("Sanatorium Report," 1907, p. 18).

derived from oxen and pigs, chiefly as raw milk from cows suffering from tuberculosis of the udder, but also in other ways. An administration was set up to deal with this matter in Manchester in 1899, which involved the appointment of a skilled veterinary surgeon, and the framing of local and permissive legislation, giving powers to some authorities to supervise and to a certain extent control admission into their area of such contaminated milk.

Ultimately, reliance is upon the bacteriological examination of milk. But the veterinary surgeon has other important work to do. He has to advise the farmer, whom he visits, as to the conditions which should lead him to suspect tuberculosis of the udder, and it is desirable that all farmers supplying the district should have clear printed directions as to this put into his hands. The veterinary officer will also advise with farmers as to the selection of stock, so as to diminish as much as possible the incidence of tuberculosis of the udder. There is also much to be gained by his instruction as to the methods by which cows and cowsheds may be kept free from contamination by fæcal and other contaminations, especially at the period of milking, and again, in the methods of dairying, so as to avoid the introduction of impurities into milk, and how milk may be kept as at low a temperature as possible. He will give help in securing the purity of drinking supplies, and will give useful aid to farmers in many ways. It is thus essential that the veterinary officer be chosen with much care.

(2) Voluntary notification of pulmonary tuberculosis was established about the same time in several areas, and in Sheffield was made compulsory in 1903. Very little power was thus obtained to deal stringently with the disease, as it was feared that the movement would be hindered, and that progress would be arrested if the disease were plainly catalogued and recognised as infectious.

When a system of notification is introduced, if administrative measures are to be carried out to the best advantage, it is desirable and probably requisite that first of all a complete investigation should be schemed out, as exhaustive as possible, into all the conditions under which a notified case has become infected or developed to its present stage, so as to secure as clear a view as possible of the etiology of the case, and of the conditions to be guarded against.

A carefully framed form of enquiry should be carefully filled up by specially trained visitors. Visits should be paid regularly to see that the house is cleaned and kept clean and to arrange for any disinfection that may be advisable from time to time.

The consumptive person is to be told that there is no one to whom neglected expectorations are more dangerous than to himself. He must not swallow his expectoration, as it is liable to set up tuberculosis of the bowel, thus extending his disease. His expectorations are to be deposited in some receptacle, of such a kind that the sputum cannot be easily lodged in it. A consumptive, when expectorating outside the house, should carry a pocket spittoon of glass which may have two lids, top and bottom. This is easy to clean. Care should be taken that the sputum reaches the interior. The bottle is made easy to empty with a little washing soda. It is then boiled in a pan kept for the purpose with a little soda. To prevent it soiling the pocket it may be wrapped in a prepared handkerchief. In cleaning these bottles they must be put into cold water and slowly raised to boiling-point, otherwise there is much danger of breakage. It is desirable to distribute minute printed directions to consumptives on how to use these bottles. When furnished with the necessary materials and directions the consumptive can avoid soiling his clothes or any surfaces. His lips can be wiped with prepared paper, and his hands can be washed.

With adequate painstaking instruction and care, the presence of a consumptive in a household can be rendered safe for the other inmates, though it is still necessary that he should have at least a separate bed. If he has been trained to live in the open air, he requires a separate bedroom and the windows open. In that case his bedclothes must be warm, and the loan of a bed becomes part of public health equipment. To reduce the risk of progressive infection still further his family should be kept well nourished. It has therefore come to be regarded as an important feature of preventive work that a special fund should be provided by the public health authority out of which assistance is given to poor households, in kind, by dietaries calculated to provide good nourishment as economically as possible.

But there are circumstances and persons where such reliance is out of the question, and where, therefore, other less reliable measures must be adopted. Thus in common lodging-houses it is necessary to place in each room placards prohibiting spitting on the clothing, floor, walls, etc., and to enforce such prohibition. The cleansing of such places requires also to be jealously watched and attended to. Again in public-houses similar notices should be placed in every public room, and where spittoons are used they should not contain sawdust, but only water. Again frequent supervision is needed.

Printed placards about spitting should also be supplied to workshops, and special attention should be drawn to the danger of spitting in closets. The best form of spittoon for workshops is undoubtedly the hand spittoon charged with water or disinfectant, and placed in some convenient spot.

Every local authority should obtain and enforce the prohibition of spitting in public places. It is astonishing how great an improvement can thus be secured in a comparatively short time.

When the National Insurance Act, 1911, became law, special provision was made available for the treatment of insured persons suffering from tuberculosis, described under the Act as " sanatorium benefit " to be administered under the immediate control of the local insurance committee created under the Act, and to be administered by these committees under regulations to be framed by the National Insurance Commissioners. " Sanatorium benefit " has now ceased to be administered by Insurance Committees.

It was necessary that each case admitted to such sanatorium benefit should be individually nominated to it by the local insurance committee. No power was conferred on local insurance committees themselves to provide institutions for treatment, but they were enabled under the Act to enter into agreement with any person or authority (other than poor law authority) to make the necessary provision. In virtue of the National Insurance Act and of the Finance Act, 1911, a sum of £1,500,000 was made available for the purpose of providing and making grants in aid to sanatoria and other institutions in the United Kingdom.

In order to start the machinery, Insurance Committees were authorised to obtain the advice and assistance of medical officers of health, and in fact it was evident that the allocation of sanatorium benefit could not be made without skilled medical advice.

A Departmental Committee was appointed to report upon the considerations of general policy in respect of the problem of tuberculosis in the United Kingdom in its preventive, curative and other aspects, which should guide the government and other local bodies in making or aiding provision for the treatment of tuberculosis in sanatoria or other institutions or otherwise. Meanwhile the Local Government Board in England had issued successive orders making it compulsory on poor law and other institutions, and practitioners to notify to the public health authority all cases of pulmonary tuberculosis coming to their knowledge, and finally under the Public Health (Tuberculosis) Regulations, 1912, which came into force February 1, 1913, they required all medical practitioners to notify to the public health authority all forms of tuberculosis, ascertained by clinical methods of diagnosis.

The Departmental Committee, in their Interim Report, recommended that the scheme for dealing with tuberculosis should be available for the whole community and should embrace measures for prevention and an organisation for the detection of the disease at the earliest possible moment. The importance of correlating the existing activities was insisted upon, and the need for utilising all available provision for treatment.

Sanatorium treatment was explained to embrace a wide course of education of the patient and a course of therapeutics. To complete existing public health administration in respect of tuberculosis the committee recommended the establishment and equipment of two units. The first unit is the tuberculosis dispensary or an equivalent staff. The second unit consists of sanatoria, hospitals, etc., in which institutional treatment is to be given (sanatoria, hospitals, colonies, open-air schools, etc.). A third unit might have been added, designated, domiciliary treatment.

The Tuberculosis Dispensary is to function as :—

(1) Receiving house and centre of diagnosis.
(2) Clearing house and centre for observation.
(3) Centre for curative treatment.
(4) Centre for the examination of contacts.
(5) Centre for " after care."
(6) Information bureau and educational centre.

In fact it stands in the centre between the medical officer of health, the medical practitioner and the home, the various institutions for treatment under the scheme, the voluntary hospitals, voluntary societies, the local insurance committees, etc., etc. It is to be the business centre, and the centre for consultation. But the various activities need not all be worked from the dispensary. The essential feature is that they are all to be carried on by the tuberculosis officer who is to be the real co-ordinating agency.

The Committee suggested that in general one tuberculosis dispensary would be required for every 150,000 to 200,000 of population ; it should be provided with a medical, nursing, secretarial and dispensing staff. The rural dispensary will for the most part be an office which the county tuberculosis officer will periodically visit, and where he will examine cases.

The care committee business is important. They will investigate cases, carry out inquiries in association with the different social agencies of the district, determine the amount and kind of assistance which should be given in particular cases, whether to the family or to the patient, consider changes of occupation, and take such steps as may be practicable to obtain suitable occupations.

The second unit of the scheme embraces sanatoria, hospitals, and other institutions.

It was strongly recommended that an individual sanatorium should not contain less than 100 beds, that the cost per bed should not exceed £150, and the cost of maintenance should not exceed 25*s.* to 30*s.* a week. The sanatorium should not be too far from a station. The site should be large enough to allow of the erection of workshops, the making of a kitchen garden, farm, etc. " Half an acre per person should be provided, but less might suffice."

" In addition to a medical superintendent, there should be two resident medical officers for an institution of 200 beds, and one resident medical officer for an institution of 100 beds."

As regards hospital accommodation, existing accommodation should be utilised as far as possible.

The number of beds required was evidently large. The committee made a rough estimate of 1 bed per 5,000 of population in addition to poor law beds. The consideration of accommodation for special purposes was reserved. Existing voluntary associations should be utilised subject to their being approved by the Local Government Board, and also to their falling into the general scheme.

Position of the General Medical Practitioner—It was considered essential that the hearty co-operation and interest of the general medical practitioners should be secured. This is, of course, a vital point, so that treatment at home may be properly carried out on sanatorium principles. It is of the utmost importance that the tuberculosis officer should have the confidence and goodwill of medical practitioners. One important part of his duties will be the consultations which he has with practitioners, another will be the preparation and diffusion of advice as to " domiciliary sanatorium " treatment.

Children—More attention should be given to the prevention of infection in children.[1] A considerable amount of voluntary work has already been done in the treatment of non-pulmonary tuberculosis, in which the education authority has taken its share. The Departmental Committee considered that:

(*a*) Children suffering from pulmonary tuberculosis should, whenever practicable, be sent to residential sanatorium schools.

(*b*) Children affected with tuberculosis should be sent to residential sanatorium schools, equipped with all necessary appliances for conservative surgical treatment. To begin with, at least 2,000 additional beds are needed.

(*c*) Glandular and other forms of tuberculosis should mainly be dealt with by means of open-air schools, playground classes, night camps, etc. It is urgently necessary that accommodation of this character should be considerably extended and made available throughout the country.

The school medical officer should be in intimate relation with the tuberculosis dispensary.

Administration in England and Wales—The Committee were of opinion that the unit area of administration should generally be that of the county, county borough, or in some cases a group of counties and county boroughs, and that in formulating a complete scheme, it should consult the other sanitary authorities, and also the insurance committees which are interested. This was in effect the policy adopted, and it had the effect of dividing the public health preventive measures from the measures directed to treatment, except in so far as the two were co-ordinated by the county tuberculosis officer. Where it was possible to get the two sets of measures united under one head, as would naturally be done where the tuberculosis officer was interested in public health measures, a decided gain resulted both in economy and efficiency.

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[1] A tuberculous mother should, of course, not be allowed to nurse her child. The desirability of removing children from their homes to the country, where they will be in healthy surroundings, is the key-note of the " Grancher " system which has been in operation in Paris since early in the present century. See paper by Dr. P. F. Armand Delille (" Trans. Tuberc. Conf.," 1921).

The Committee recommended that capital grants should be made up to four-fifths of the amount required to encourage the early provision and equipment of tuberculosis dispensaries, and that for the provision of additional sanatorium beds for adults required at the outset, capital grants should be made up to three-fifths of the cost per bed, the total sum not to exceed £90 per bed.

The Committee recommended that schemes dealing with the whole population should be drawn up by councils of counties and county boroughs, or by combinations of these bodies at the earliest possible date (with the necessary modifications for Scotland). In their Final Report the Committee announced that in a letter from the Chancellor of the Exchequer (Mr. Henry Hobhouse), bearing date July 31, 1912, he had decided to place at the disposal of the Local Government Boards and of the Welsh Commissioners respectively a sum of money which would represent approximately half the estimated cost of treating non-insured persons as well as the dependants of insured persons. The effect was to make approved schemes available for the whole population.

He had also decided to allocate 6*d*. out of the estimated amount of 1*s*. 3*d*. per insured person, available for the treatment of insured persons, for the purpose of defraying the cost of treatment by practitioners in the home.[1]

In connection with the spread of the disease by means of infection from one human being to another, special emphasis is laid on the importance of early diagnosis and the use which may be made of the dispensary to that end. The Committee also discussed methods of increasing the powers of resistance, by improvements in housing, personal habits, clothing and feeding.

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[1] This 6*d*., however, was afterwards pooled with the rest of the money available for the payment of the medical benefit, and therefore ceased to be specially applicable to the treatment of tuberculosis, a very unfortunate step, as it not only diverted the tuberculosis revenue to the treatment of other diseases but took away an important weapon in securing the co-operation of practitioners. In this report the Committee proposed to deal with questions relating to prevention, with special reference to bovine tuberculosis and tuberculosis in children, and with the application of the 1*d*. available for research.

The Committee considered that a sum of about £200,000 was required for the provision of institutions for children. The last section of the final report is concerned with the elaboration of a scheme of research which need not, however, be summarised here.

In all schemes for the reduction of tuberculosis the great difficulty is the reduced economic value of persons who have become affected with the disease, a difficulty which pursues every step taken. In addition to other measures of alleviation of the economic position, the National Insurance Act, besides the provision of sanatorium benefit, confers sickness benefit which consists in periodical payments to insured persons whilst rendered incapable of work, for a period not exceeding 26 weeks in all.

Disablement benefit is a continuation of the periodical payments at a lower rate in respect of incapacity after the period of sickness benefit has been exhausted.

The Local Government Board and the Insurance Commissioners expressed their general approval of the recommendations of the Departmental Committee, and the Local Government Board in the course of a Circular of May 14, 1912, suggest that County Councils, Councils of County Boroughs or Joint Committees of Local Authorities should forthwith take the question of framing a scheme for giving effect to the recommendations of the Committee in reference to the treatment of tuberculosis into serious consideration.

The Board issued a Memorandum in February, 1913, on the construction of the new buildings which would be needed in the erection of sanatoria, accompanied by plans, and in February, 1914, they issued a much more complete memorandum on the same subject with model plans, and setting forth the requisites of new residential institutions in full detail.

On July 26, 1912, the Board issued a general order to the Council of every county and of every sanitary district in England and Wales on the domiciliary treatment of tuberculosis, approving of the treatment of insured persons by registered medical practitioners under certain conditions, amongst which were (Article II, 2), that the medical practitioner give the patient such instructions as are required as to his mode of living, diet, rest and work, and as to precautions necessary to protect the patient against re-infection.

He is also to keep certain records and from time to time inform the Medical Officer of Health of the sanitary district in which the patient resides, of any circumstances known to the medical practitioner which may adversely affect the sanitary conditions under which the patient is living, and in respect to which action by the medical officer of health or of the sanitary authority would, in the opinion of the medical practitioner, be necessary or desirable.

This Order if properly carried out was admirably calculated to maintain a close relation between the practitioner, the medical officer of health, and the tuberculosis officer, and to produce an improvement both in prevention and treatment.

By the Public Health (Tuberculosis) Regulations, December, 1912, the Local Government Board made all forms of tuberculosis notifiable by medical practitioners, prescribed the duties of medical officers of health, conferred large powers on Local Authorities, and prescribed forms of notification to be used in different circumstances. These powers were in effect restricted by Article XVI which prescribed that:

> " Nothing in these regulations shall have effect so as to apply or so to authorise or require a medical officer of health or a local authority, or any other person or authority, directly or indirectly, to put in force with respect to any person, in relation to whom a notification in pursuance of these regulations has been transmitted to a medical officer of health, any enactment which renders the person, or any one in charge of the person, or any other person, liable to a penalty, or subjects the person to any restriction, prohibition or disability affecting himself or his employment, occupation, or means of livelihood on the ground of his suffering from tuberculosis."

For removal of names of ex-tuberculous patients for the tuberculosis register see Circular 549 Ministry of Health and Public Health (Tuberculosis) Regulations, 1921.

Notwithstanding the general indications of the Departmental Committee, the judgment of different authorities varied widely as to the numbers of beds required and attainable respectively for sanatorium and hospital treatment, or as to both. The initial schemes were to no small extent determined by the hospitals and sanatoria already existing in the district, whether specifically dealing with tuberculosis, or only as part of general treatment, and in the case of many counties they were driven to rely for their beds on distant sanatoria, and on such extension of these as could be devised.

As regards children, provision for both pulmonary and non-pulmonary forms of tuberculosis was often deficient in amount or character, and the utmost use was made therefore of such institutions as Alton, Heswall and Leasowe, of others scattered in various localities, and of the local provision made by charitable institutions. Poor Law institutions also exerted themselves to provide treatment for children.

It may be said generally that in large urban areas, the greatest need was for accommodation for advanced or middle cases, and that this arose from the fact that the demand for such accommodation was exceptionally severe both as the result of economical factors and for public health reasons. Hospitals for tuberculosis in such areas could be provided conveniently near to the centre, and patients were thus enabled to see their friends. This was not the case in county areas, and the tendency in these, therefore, was to provide beds in sanatoria, with very little provision made for middle and advanced cases. One result of the small number of beds provided for advanced cases, was that existing sanatoria were at first under difficulties owing to the unsuitable class of cases sent to them.

In the Annual Report of the Chief Medical Officer to the Ministry of Health for 1919–20 it is stated that at this period, for domiciliary and dispensary treatment there had been established 398 dispensaries. The number of tuberculosis officers appointed was 300, 176 sanatoria had been provided with 9,600 beds. Approved hospitals for pulmonary and non-pulmonary cases furnished 3,800 beds for adults and 2,300 for children. The institutions approved by the Local Government Board and the Ministry of Health up to March 31, 1920, were as follows :

Classes of Institutions.	Number of Institutions Provided by		Number of Beds Provided by	
	a Local Authority.	Voluntary.	a Local Authority.	Voluntary.
Sanatoria	97	79	4,872	4,752
Isolation hospitals, including small-pox hospitals . .	83	—	3,392	—
General hospitals	—	86	—	447
Children's institutions . .	10	33	581	1,737
	190	198	8,845	6,936
	398		15,781	

Not long after the initiation of schemes of treatment disappointment was experienced in regard to the results of sanatorium and hospital treatment. After three or four months' treatment many cases had improved and there being pressure for accommodation, they were discharged, and resumed their employment, with the result that the improvement attained was speedily lost. This was no new experience, for the same disappointment had been previously experienced under the German insurance scheme.

Attempts were made in various ways to meet the situation. The National Insurance Act provided sickness and disablement benefit which, however valuable in illness of short duration, went but a little way to cope with the loss entailed on individuals by tuberculosis.

Another improvement was introduced by the superintendents of sanatoria, especially by Paterson and Bardswell. One of the great difficulties in sanatorium treatment was that, leading an unoccupied life, and generously dieted, the patients became demoralised mentally, and " soft " physically, that is to say apt to run down when again faced with employment. The new method consisted in the introduction as a part of treatment of graduated tasks, the patient being taken from one carefully calculated task to another heavier one, step by step, always regulated and controlled by medical supervision and treatment. There was, however, one disadvantage which attached to this mode of treatment, namely, that the graduated tasks, though they did hold out a hope of physical improvement, and were put forward as part of medical treatment, gave no assurance to the patient that he was being raised in the scale of employment and becoming capable of earning his living.

Hence arose the further suggestion that patients should be trained in definite employments, and provided with instructors, preferably themselves ex-sanatorium patients, who could appreciate and allow for fluctuations in working capacity. It was also proposed that payments should be made as a further encouragement, based on the value to the institution of the work turned out by the patient under training. As far as possible the work was to be of the same character as that previously followed by the patient, or such as he might hope to procure.

Undoubtedly these steps in institutional treatment were of the utmost value to the patients, both physically and mentally, and it was then seen that it was of the greatest moment that all persons in a hospital or sanatorium, whose conditions permitted it, should have occupation planned out for them of a character which they could safely undertake. No doubt this ideal is not easy to realise, and cannot be attained without great effort and additional expense. But it is calculated to change the whole tone of the institution, and introduces a new spirit of hopefulness and enterprise, reduces the tendency to loafing and mischief, and improves discipline.

But enterprising physicians were led to consider further whether the relapses which occurred after a course of sanatorium treatment could not be averted in suitable cases by extension of supervised treatment under new and more favourable conditions. Hence the idea of a colony naturally suggested itself. Apparently it was hoped that selected cases might be so far trained in farm work, that besides obtaining the complete arrest of their disease, they might be able to emigrate to the colonies with safety, and there face the inevitable hardships of a farm life. It is true subsequent experience does not favour this outlet, since not to mention the refusal of the colonies to accept cases of healed phthisis, there are but few town cases who will accept the hard work and reduced earnings of agricultural work, even in the form of market gardening or small holdings, besides other deprivations to which they and their families are subject. Nevertheless this was the beginning of a new and hopeful effort.

Gradually colonies were founded for the reception of arrested cases of phthisis. For the most part those who projected them considered that it was unsafe to receive cases of advanced phthisis, however much they might have improved, and their idea was to receive only selected cases who had so far recovered from the earlier stages of the disease, that under some amount of medical supervision they could be trusted to carry on safely some employment for which they were to receive special training. This employment was at first mostly agricultural or of an allied character, market-gardening, pig-keeping, poultry-farming, horticulture, forestry. In those cases in which the patient's employment had to be changed, the training given at first was such as would enable him to live in a village or in the suburbs of a town, and would not require much equipment in machinery.

Varrier Jones had already established such a settlement at Papworth in Cambridgeshire. It consists of an estate of 350 acres with a large country house as its centre. The institution, which has at present accommodation for about 120 patients, comprises:

(*a*) A sanatorium and hospital.

(*b*) The training colony section. Patients whose condition improves and who pass to this section are accommodated in shelters in the grounds.

(*c*) The village settlement with some 70 to 80 cottages.

These sections also mark three stages in the progress of the patient. During his course of training as his capacity increases he receives pay for his work. After six months in the training colony section the patient is offered permanent employment with housing accommodation in the village settlement, and in every case up to the present the offer has been accepted: his family may or may not live with him.

In 1920 provision had been made by English county councils of 14 "farm colonies," while 4 were under consideration in Wales.

Open-air schools, another important development, had made great headway, though the precise character of such schools is not always clear, that is to say, whether they were for surgical tuberculosis, pre-tuberculous cases, or what. In English counties, 18 open-air schools had been provided, while 4 were under consideration; in English county boroughs, 26 had been provided, while 12 were under consideration. In Scottish counties, 2 open-air schools had been provided and 4 were under consideration. In burghs, 5 open-air schools had been provided.

By the creation of schemes for the treatment of tuberculosis an immense stride forward has been taken in the campaign against tuberculosis. The appointment of tuberculosis officers, specially qualified and devoted to the administration and study of the disease, has introduced a new and invigorating force. Were his field of vision limited to examination of patients and contacts, and to the administrative work involved in determining the movement of cases, and the condition of domiciliary patients, expectations of the advance to be derived from the new schemes would be partially disappointed. But, even in his capacity of consulting medical officer to practitioners, he is bound to exert a powerful influence, quickening up the early diagnosis of the disease, and supplying the deficiencies of the medical schools as regards instruction in a knowledge of signs and symptoms.

J. NIVEN.

TUBERCULOSIS CIRCULARS ISSUED BY LOCAL GOVERNMENT BOARD AND MINISTRY OF HEALTH

14th May, 1912. Parliamentary Grants for Sanatorium Purposes.
6th July, 1912. Treatment of Tuberculosis. Provisional and Permanent Arrangements (Memo. 102/IC and 112/IC).
26th July, 1912. Domiciliary treatment of tuberculosis. General Order 59221.
6th Dec. 1912. Schemes for Institutional Treatment.
20th Dec. 1912. Public Health (Tuberculosis) Regulations, 1912 (Order 59247).
Feb. 1913 (Memo.). Construction and arrangement of Inexpensive Buildings.
April, 1913. Benefits of deposit contributors. 142/IC.
14th May, 1913. Maintenance Grant claim (15/7/12 to 31/3/13).
7th Nov. 1913. Maintenance Grant and organisation of schemes.
19th Dec. 1913. Treatment of Tuberculosis in London.
13th Feb. 1914. Forwarding Memorandum on provision of new Institutions for treatment of Pulmonary Tuberculosis.
9th May, 1914. Maintenance Grant.
29th April, 1915. (2) Schemes. Development and completion.
11th April, 1916. Maintenance Grant.
17th Oct. 1918. Application of Food Rationing Scheme.
25th Oct. 1918. Shortage of residential accommodation owing to war conditions.
4th Dec. 1918. Discharged Soldiers and Sailors—Home visiting, etc.
28th Dec. 1918. Residential Treatment for ex-service men. Memo. 233 A.I.C. and Model agreement.
No. 19. 15th Sept. 1919. Ex-Service Men (examinations and reports). M. of P. Circular 135, and Record Card.
No. 34. 3rd Nov. 1919. Additional Residential accommodation—Capital Grant.
No. 73. 9th March, 1920. Provision of further residential accommodation. Reminder as to submission of proposals.
No. 103. 23rd June, 1920. Further to Circulars 34 and 73.
No. 140. 14th Oct. 1920. Pensions of Ex-Service Men leaving Sanatoria. (M. of P. Circular 1033 of 17.6.20. From M.P.M.S.D. 71.)
No. 149. 3rd Dec. 1920. Metropolitan Borough Dispensary Schemes.
No. 174. 17th March, 1921. Payment of Grant (M. & C.W. Tuberculosis and Venereal Diseases). Procedure and Amount.
No. 179. 21st Feb. 1921. Ex-Service men. Certificates by Tuberculosis Officers, in regard to incapacity for remunerative work.

No. 190. 31st March, 1921. General Arrangements upon termination of Sanatorium Benefit. (Memos. 30 T. 31/T, 30A/T. 30 B/T. Termination of Sanatorium Benefit Regulations and Medical Benefit (No. 2) Regulations, 1921.

No. 192. 31st March, 1921. Maintenance Grant. Payment of, for 1920/21 and 1921/22.

No. 196. 21st April, 1921. Public Health (Tuberculosis) Regulations, 1921, and Order 67084.

No. 198. 16th April, 1921. Metropolitan Boroughs. Model Agreement for use in cases where dispensary scheme provides for the use of a Dispensary established by a Hospital Authority or other voluntary body.

No. 208. 20th May, 1921. Domiciliary treatment of insured persons. Reports by Medical Practitioners (Procedure).

No. 208A. ,, ,, Med. Ben. Amendment Regns. (No. 2), 1921. No. 733 and Memo. 48 T.

No. 219. 18th July, 1921. Conference between Chief T.O.'s and Ministry.

No. 231. 22nd Aug. 1921. Australia—examination of emigrants who have suffered from Tuberculosis.

No. 246. 23rd Sept. 1921. Termination of War. T.B. ex-service men.

No. 246A. ,, ,, Payment of Tuberculosis Officers for Ministry of Pensions Services. Form T. 65.

No. 248. 1st Oct. 1921. Treatment of T.B. Ex-service men—Claim for repayment of cost.

No. 257. 3rd Nov. 1921. Rationing arrangements for expenditure in 1922–23. Form T. 66 and list 14.

No. 271. 13th Dec. 1921. Treatment of Seamen. Advisory Committee Order 1535.

No. 280. 17th Jan. 1922. Residential treatment—Selection of patients, duration of treatment, and cost.

No. 295. 18th March, 1922. Basis of Grants. (Committee on National Expenditure.)

No. 304. 28th April, 1922. Ex-service men. Duties of D.C.M.S.'s (T.B., etc.) duration of treatment, leave, etc. Form M.P.M.S.D. 122. Instruction as to record card, T.S. 15A, etc.

No. 307. 29th April, 1922. Ex-service men. Special arrangements in regard to concurrent treatment and vocational training:—(M. of P. instructions, Forms M.P.M.S.D. 117, 118, 119, 120, and T. 70.)

No. 308. 8th May, 1922. After care in London.

No. 313. 24th May, 1922. Residential treatment of ex-service men. Claims for payment.

No. 324 } London, 30th June, 1922. Return of work in connection
No. 324A } with tuberculosis dispensaries. Form "R" (revised).

No. 326. 10th July, 1922. Treatment combined with Training, Form T. 76.

No. 323. 17th July, 1922. Sanatoria—costings.

No. 334. 23rd Aug. 1922 Vocational Training of ex-service men.

No. 345. 21st Oct. 1922. Claim for residential treatment of ex-service men. T. 64A.
No. 344. 27th Oct. 1922. Rationing Arrangements for expenditure in 1923–24. T. 84.
Memo. 72/T. Vacancies for T.B. ex-service men at Preston Hall and Papworth Colony.
No. 371. 20th Jan. 1923. Additional Accommodation at Preston Hall for vocational training of ex-service men.
No. 373. 24th Jan. 1923. Summary of Notifications during 1922. T. 88.
Memo. 78. Monthly return of cases receiving or awaiting residential treatment.
No. 394. 28th April, 1923. Special services rendered by T.O.'s for the M. of P. Form T. 91.
No. 395. 4th May, 1923. Ex-service men: Treatment allowances. Art. 9 of Royal Warrant and Modification of Sec. 6 of Memo. 30/T: Special forms of treatment.
Memo. 81. M.C.W. May, 1923. Payment of Grant, year ended 31/3/23. T.B. (F. 7), T.B. (F. 8).
No. 425. 2nd Aug. 1923. Failure of Practitioners to notify cases of T.B.
Memo. 83/T. 22nd Aug. 1923. Termination of Vocational training postponed until 31/12/24.
Lists 14, 14a, 14b, 14c, 14d., 14e, 14f, 14g, 14h, 14j. Approved charges for residential treatment.
List 10A (April, 1923). List of approved Sanatoria, etc.
No. 549. 22nd Dec. 1924. On Public Health (Tuberculosis) Regulations, 1912 and 1921.

In view of the unreasonable alarm felt by the public as to the infectivity of tuberculosis, the Royal College of Physicians, London, issued a statement; *inter alia* it says when suitable "precautionary measures" are carried out "risk of infection is reduced to a minimum"; further, that "no risk is incurred by living in the immediate neighbourhood of institutions for the treatment of tuberculosis which are properly conducted." See p. lxii of the Supplement to the 43rd Annual Report of the Local Government Board for 1913–14.

CHAPTER VIII

INFECTION—IMMUNITY

HIRSCH nearly half a century ago observed "few departments of medicine have grown so much as that of parasitology." When he wrote, the germ theory, under the influence of Pasteur's work, was beginning to arrest attention; and in "the eighties," stimulated by the researches of Koch and his disciples, the study of pathogenic bacteria made remarkable progress. Later, the work of Manson and Ross, on malaria, brought into prominence the discovery made by Laveran, as long ago as 1880, of Laveran's crescent-bodies, and this led to the devotion of much attention to the Protozoa as possible causes of disease. Later still, it was realised that the field must be still further widened, and that forms of life more minute than the ordinary germs of bacteriology—the ultra-visible viruses—must also be deemed deserving of study. The demonstration by De Schweinitz in 1903 of the fact that hog cholera, a disease prevailing epidemically among swine, was due to a "filter passer," and not as had been previously supposed to the hog cholera bacillus, and the consequential degradation of the latter to the rank merely of an "associated organism," tended to increase the growing interest in ultravisible viruses; and McFadyean, in 1908, was able to refer to nearly a dozen forms of epidemic disease in animals held to be due to ultramicroscopic germs.

While the study of causal and associated organisms was thus assiduously prosecuted, it became more and more realised that attention should not be too exclusively focused upon the germ, but that the reaction shown by the host when attacked by the parasite also merited attention, and study has of late years been increasingly directed to the very difficult problems of immunity.

Furthermore, the demonstration of the important part played in disease by water, milk and other foods, by insect and other vectors, and the interest taken in the influence exerted in various and hitherto unexpected ways by environment generally, have led to a much broader outlook as regards epidemiological problems. Thus, in 1908, Hottinger, in discussing the application of Koch's postulates to the particular case of the hog-cholera bacillus, declared that Koch's four conditions should be enlarged, "by the addition of a requirement that the infectious character be exhibited by inoculated animals," and, speaking more generally, he adds, the condition should be insisted upon that the artificially produced disease must "fulfil the requirements of epidemiology."

In modern phraseology an epidemic disease is "not so much an *entity* as a *resultant*; it is the result, in fact, of an *interaction* between two opposite forces, the infecting agent and its host . . ." and as these are both living organisms they "are liable to be influenced by their environment" and subject, therefore, "to some variation, the precise degree of which has by no means yet been adequately determined." (M. H. Gordon, "Proc. Roy. Soc. Med.," Feb., 1909). The same writer lays special stress, moreover, on "the physical condition of the environment, especially in regard to temperature and humidity, factors that may be more related to the phenomena of the seasonal incidence of disease than is yet realised."

Spread of Infection.—Organisms are classed as parasitic and saprophytic, and four groups, obligatory and facultative parasites, and obligatory and facultative saprophytes, may be distinguished. The organism of rabies is an *obligatory parasite.* In the case of such a disease the "stamping out" process by means of isolation, etc., might be expected to prove especially efficacious. Syphilis, glanders, variola, and measles, too, are almost always directly contagious from person to person. Among *facultative saprophytes* the organisms which cause actinomycosis and erysipelas, and the pathogenic cocci which are associated with pyæmic conditions, may be particularly referred to. As examples of *facultative parasites*, anthrax, cholera, typhoid and tetanus bacilli may be cited. *Obligatory saprophytes* are not directly concerned in the production of infectious disease, though they may elaborate poisons capable of giving rise to symptoms of a specific character.

The measures to be adopted in dealing with maladies usually transmitted to man by animals obviously differ from those which must be employed in instances in which the disease is generally communicated from man to man. Rabies in the dog has been effectively combated by muzzling orders, and by quarantining dogs newly arriving in particular localities. Glanders has been attacked by destroying affected horses, and with special success since the use of mallein, as a diagnostic agent, has facilitated recognition of the disease in its early stages. Among cow maladies tuberculosis stands pre-eminent as a source of mischief in man, and the need of excluding from milk supplies the milk of cows affected with tubercular disease of the udder has been increasingly realised of late years. Scarlet fever, diphtheria, and enteric fever have been not infrequently spread by milk. Attention has been given to the necessity of obviating, by an adequate system of inspection, risk of spread of tuberculosis by the consumption of tuberculous meat. The possibility of other bacterial diseases (actinomycosis and anthrax for example) and of higher parasitic forms being transmitted to man by infected meat needs to be borne in mind. Other kinds of food may act as disease producers : the dissemination of enteric fever by fish and shell-fish, and the numerous recorded instances of "food poisoning," are cases in point.

Communication of disease to man, by infective material derived from a previous case of illness, often occurs in a roundabout way. Excremental matter containing the specific germs of enteric fever and cholera, and, perhaps, of other diseases, may by means of water be conveyed considerable distances. Clothing has been supposed capable of long retaining the power of reproducing scarlet fever ; and ability to produce disease has been ascribed to mucus in diphtheria, to the saliva in rabies, to purulent discharges in scarlet fever and other diseases, and to dried small-pox crusts, etc. The spread of disease by fomites is probably not of such frequent occurrence as it was at one time supposed to be. It was realised years ago that the infection of typhus is remarkable inasmuch as it is only conveyed, as a rule, through very small distances ; it is now recognised that verminous infestation is the condition favourable to the spread of this disease, together with gross overcrowding. The breath presumably acts as a source of infection in measles, whooping-cough, influenza, mumps, and possibly in pneumonia and small-pox. Dried sputa are assumed to be operative in promoting the spread of phthisis.

As has been already mentioned, the soil is supposed to be a medium which favours, under appropriate conditions, the growth of certain germs which cause disease. The existence of the anthrax, tetanus, and malignant œdema organisms in soil has been repeatedly demonstrated. Enteric fever, diphtheria, cholera, summer diarrhœa, and numerous other diseases have been from time to time studied in connection with soil states. The discovery of the *rôle* played by the mosquito, in filariasis and malaria, has led to direction of special attention to the possibility of other maladies being spread by the agency of blood-sucking insects. Experiments have been made which indicate that the mosquito can transmit the poison of yellow fever. In this connection, moreover, the tsetse fly disease may be referred to. It had long been believed that the tsetse fly (*Glossina morsitans*) was concerned in producing the "fly disease" which is apt to affect animals in some parts of Central Africa. Bruce showed in 1894 that the fly transmitted the disease by transferring a protozoon (trypanosoma) from infected to uninfected animals. The trypanosome is allied to the organism which causes the disease known in India as "surra" : again another allied form of organism is found in European rats. The "surra" disease does not, as a rule, affect bovines, whereas the tsetse fly disease does. Another interesting point is the fact that the fly disease vanishes with the disappearance of large game from a district. The *Trypanosoma Gambiense,* which is conveyed by a tsetse fly, the *Glossina palpalis,* is the cause of the human sleeping sickness of West and Central Africa. The *rôle* of the rat flea in plague, of the pediculus in typhus, and the possible part played by the house-fly in diarrhœa may also be referred to.

Epidemic and Endemic Diseases—Some diseases tend to establish themselves permanently in particular localities, notably, for example, cholera in special areas in India, small-pox in the Soudan, and plague, malaria, yellow fever, dysentery, etc., in other parts of the world. When a disease so establishes itself it is said to be *endemic* in the population concerned. Again, diseases which from time to time become widely prevalent, while at intervening periods there is more or less complete freedom from their ravages, are said to be *epidemic* in relation to the populations they affect during their times of activity. Originally the expression epidemic disease was applied to any disease which attacked many persons at the same time, and, even in recent years, writers on epidemic diseases have made reference to such maladies as ergotism, scurvy, and the dancing mania of the Middle Ages. The modern use of the word is, as a rule, a more limited one; thus Davidson restricts the term epidemic "to that group of infective or microparasitic maladies which has the common property of spreading from time to time in a community," excluding intoxications, dietetic, and psychical diseases, as well as those arising from physical agencies such as heat and cold.

Soil conditions may play an important part in determining endemicity of disease, climatic conditions, too, are of importance; recent research has caused attention to be directed to search for intermediate hosts, in the case of maladies which especially occur in particular areas. Further, the habits and social circumstances of populations need to be borne in mind. A disease may be endemic in one or more localities, and from time to time show ability to become epidemic in other places. If the disease spreads over a large portion of the globe, as, for example, plague and cholera have done in the past, it is said to become pandemic. The same disease may be, therefore, endemic as regards special areas and epidemic as regards other areas. As Davidson observes, "The converse of epidemic is not endemic but sporadic," and, he adds "an epidemic disease often occurs sporadically in inter-epidemic periods." The inability of the disease to produce more than a few scattered cases may depend upon attenuation of the virus, upon the absence of conditions necessary for the widespread diffusion of the disease, or upon insusceptibility on the part of the population generally. Diseases may be of fairly constant occurrence in particular communities, and yet from time to time exhibit cyclical variations of prevalence. Precise study of the phenomena of periodicity has only been undertaken in quite recent years, for the necessary statistical data have only become available within the last three quarters of a century.

Periodicity—With the ancients, study of periodicity in disease was undertaken in relation to the symptoms of certain maladies; thus the doctrine of "critical days" in fevers arose out of consideration as to whether, on special days, particular symptoms appeared which enabled a forecast as to the probable course of the malady to be made. The modern conception of periodicity as affecting, not merely the course of a particular malady, but the phenomena of widespread prevalences of disease, was foreshadowed by Sydenham. The fluctuation in the prevalence of certain diseases at different seasons of the year was made the subject of exact study by Buchan and Mitchell. Their researches, in addition to throwing light on seasonal prevalence, greatly stimulated inquiry with regard to the fluctuations which have been shown to occur when long periods of time are passed in review. Laycock and Edward Smith, early in the latter half of the last century, devoted much attention to the question of periodicity, and found indications, in numerous instances, that altered behaviour of disease was related to periodical recurrence of physical phenomena. Laycock held that it would be possible to establish a system of vital proleptics, or, as Netten Radcliffe, in commenting on his work, termed it, a science of pathological forecasting.

Netten Radcliffe attached special importance to "the influence of an accumulation of susceptible persons in the intervals between epidemic prevalence." He showed that, making certain assumptions with a view to simplifying the problem, a rough approximation to the number of years covered by an epidemic cycle could be obtained by dividing "the number of people attacked, or otherwise rendered insusceptible, during an epidemic," by "the annual excess of births over deaths (all causes), with other increments of susceptible population." He pointed out that variations in the numbers attacked, fluctuations in the number of susceptible people from whatever cause arising, and other influences, required to be kept in mind, and he said, "it is easy in these considerations to find reasons for differences in epidemic cycles among different communities, for differences in the intensity of successive epidemics, and for apparent alterations of susceptibility among communities, and these reasons will deserve to be considered before going in search of other reasons."

Ransome was struck by the remarkable behaviour of small-pox in Sweden in the latter half of the eighteenth century, during which period epidemics occurred with striking regularity, at intervals of about five years, up to the time when, in correspondence with the introduction of vaccination, the prevalence of the disease underwent remarkable diminution. Ransome obtained from Berg, of Stockholm, the figures relating to whooping-cough, scarlet fever, and measles in Sweden. In the case of measles, eight well-marked major prevalences occurred between 1775 and 1830, the interval between each prevalence being about six years. In the case of whooping-cough the cycles of prevalence were less distinctly marked, but some ten major prevalences were, roughly speaking, traceable, the interval being thus somewhat shorter than that noted in measles. In scarlet fever only four well-marked prevalences occurred, the intervals being about fifteen to twenty years, and thus considerably longer than in measles, whooping-cough, and small-pox.

Ransome pointed out that, in the case of scarlet fever more particularly, there were shorter cycles, in addition to the longer undulations; he compared the latter to vast waves of disease on which "the lesser epidemics show like little ripples upon the surface of an ocean swell." He sought to find an explanation of the shorter cycles on several hypotheses. On one, the "age theory," the phenomena were held to be accounted for by the fact that "certain years of life are prone to the disease, and that, when these have been cleared away, the disease could not prevail extensively until there were again persons of fit age to receive the poison." On another, explanation was sought in variations "in the powers of offence and virulence" manifested by the disease. A third hypothesis, which Ransome thought afforded the best explanation of all, was to the effect that "a certain density of the population at susceptible ages is necessary before a disease can spread with the vigour of an epidemic." According to this hypothesis the disease "can only become epidemic when the proximity between susceptible persons becomes sufficiently close for the infection to pass freely from one to the other." Ransome says, when an epidemic "has, by either a fatal or non-fatal attack, cleared away nearly all the susceptible persons in a population, mostly infants and children up to a certain age, then it must necessarily wait a certain number of years before the requisite nearness of susceptible individuals has been secured. There must, in the interval, be a gradual re-stocking of the nation with material fit for the epidemic to feed upon, and it can only spread when the requisite proximity is attained, when the meshes of the network of communication are sufficiently close to enable it to include all susceptible persons in one grand haul." Ransome thus accounted for the minor cycles; with regard to the larger undulations, which he called the "nutation periods" of diseases, he was unable to offer any explanation.

Whitelegge, in 1892, in a paper entitled "Measles Epidemics, Major and Minor," referred to minor epidemics as "occurring every year or two, and in a sense, mechanically," and suggested that the "major epidemics, the waves of long periods, were due to progressive alterations in the intensity of the measles virus." This question of "Change of type in epidemic diseases" was considered in detail, in 1893, by Whitelegge in his Milroy lectures. Putting aside "superadded waves" (annual seasonal waves, milk epidemics and water epidemics), he attributed the broader cycles to change in the quality of the disease itself. He held that the virus was able to manifest at certain periods greater severity of attack, greater power of overcoming comparative insusceptibility and greater power of epidemic diffusion. In some diseases, those of "stable type," variations of intensity of virus are little marked; in others those of "unstable type" (or "mobile diseases") the quality of the virus appears to undergo rapid and even abrupt changes in intensity.

Scarlet fever is, from this point of view, a disease of an intermediate character; but, as evidence of gradual change in the quality of this disease, Whitelegge pointed out that the hospital case-mortality from scarlet fever, from 1832 onwards, showed a rise and fall, in close correspondence with the general scarlet fever mortality, especially during the period 1859 to 1880. In measles there was some suggestion that long waves of prevalence were accompanied by variations in type; but the minor explosions, occurring at short intervals, were attributed to the fact that accumulation of susceptible persons favours spread of disease, at times when the climatic and other external conditions offer sufficiently small resistance.

The periodicity of a disease, which has become established in a particular community, undoubtedly influences to a marked extent the age-distribution of the deaths due to it. Indeed, McVail says "the periodicity of small-pox is the governing factor in its age-distribution." He points out, referring to small-pox in the eighteenth century, that in Kilmarnock and Geneva epidemics came every four or five years, and the disease was, to nine-tenths of its extent, found to affect children under five years old, "the average age at death in Kilmarnock being not much over the average age of the children born since the previous epidemic. But in Boston, U.S.A., where epidemics came every twelve years, the average age at death would be greater; and so also in country towns and villages, and in the Hebrides, Iceland, etc. In London small-pox attacks among adults appear to have been not at all uncommon, and the explanation is doubtless to be found in the largeness of the number of immigrants from country districts, where opportunities of attack were less frequent."

Protection and Immunity—The fact that an attack of a disease may confer immunity against subsequent attack has been recognised both in the case of the lower animals, and of disease affecting man himself. Thus the animal "salted" against a particular infection acquired an enhanced value. Again, the doctor or nurse who attended a case of small-pox was expected to have secured adequate protection by being properly vaccinated, while in the case of typhus, nurses who had been previously exposed to infection, were chosen for nursing those suffering from the disease.

The notion that a condition of protection against disease could be obtained, by submitting the body to the operation of the malady in a mild form, lay at the root of the ancient beliefs in the efficacy of small-pox inoculation. The Brahmins are said to have first put the question to the test of practice, employing what would be termed, in modern phraseology, an attenuated virus, obtained by storing material from cases of the disease, and conducting their operations with careful regard to diet, regimen, etc., during the progress of the treatment. Variolation is, moreover, said to have been long ago practised, in China, by applying small-pox crusts to the nostrils, and other methods have been adopted in various parts of the world. Attention was pointedly called to the question in modern times, when, early in the eighteenth century, under the auspices of Lady Mary Wortley Montagu, small-pox inoculation was introduced into this country, and the practice soon became widely extended.

Jenner's discovery, at the end of the century, by substituting vaccination for the more formidable variolation, led to the general adoption, in those civilised countries in which small-pox prevailed, of the new method, the dangers attendant upon which were seen to be insignificant in comparison with those associated with inoculation of small-pox virus. As statistical records have accumulated on a larger and larger scale, and the behaviour of small-pox in relation to vaccination has admitted of being more and more critically examined, the significance of the new departure inaugurated in 1798 has been increasingly realised. Moreover, experiments made in recent years have shown that Jenner's "variolæ vaccinæ" is, in point of fact, variola of the cow, and thus, while confirming Jenner's thesis, they have been the means of greatly stimulating inquiry upon the lines which he indicated more than a century ago.

Prior to the collection of statistics on a comprehensive scale, second attacks of small-pox were regarded, if not as altogether unknown, at least as quite exceptional; such occurrences were, no doubt, very rare in the experience of any individual observer. In the Sheffield outbreak of 1887–1888, however, in which the matter was tested, by Barry in a large population severely attacked, it was found that twenty-three persons, out of a total of 18,292, reported to have suffered from small-pox prior to 1887, again developed the disease, an attack rate of 0·13 per cent. The rate upon the Sheffield population considered as a whole was about thirteen times as great (1·7 per cent.), while that upon the unvaccinated portion of the population was more than fifty times as great (7·5 per cent.).

The frequency of occurrence of second attacks of other diseases has not been studied with precision, the necessary data not having been hitherto available on a large scale; with the growth of the system of notifying disease, increase of knowledge in this connection may be anticipated. That some forms of disease protect the sufferer against future attack is made clear, apart from evidence of the kind which has already been referred to in the case of small-pox, by certain other considerations. The normal behaviour of such diseases as measles and whooping-cough in attacking young children and sparing adults, may be mentioned. It has further been found that when, as in the Fiji epidemic of 1875, measles attacks a community containing persons who have not suffered from the disease in childhood, its incidence upon adults is marked. Moreover, precise statistical record of the ability of this disease to attack children and others, at higher ages, is forthcoming in the case of sparsely populated places, in which measles outbreaks are of infrequent occurrence. Thus, while in certain sparsely populated parts of England the deaths under five years of age constitute only 78 per cent. of the total deaths from measles, in large towns such deaths contribute 93 or 94 per cent. of the total deaths.

Small-pox, like measles nowadays, was once a disease of childhood. Thus in Kilmarnock from 1728 to 1764, outbreaks of small-pox occurred every three or four years, and 88 per cent. of the total deaths, taking the entire period, occurred in children who had been born since the height of the epidemic preceding that in which their small-pox was contracted. McVail, in 1882, in a paper, extracts from which appear in the Fourteenth Annual Report of the Medical Officer of the Local Government Board, commented upon these facts. He pointed out that the Kilmarnock population in question (some 5,000 persons) might be regarded as being composed of three groups; there were, in fact, from the point of view of small-pox, three Kilmarnocks. " One, a Kilmarnock of 3,700 persons, had no fear of its attacks. These had already met with and battled with the disease fiend. On many were to be seen the marks of the conflict. Some were blind, some had lost their hearing, many were permanently injured in constitution, and very many were scarred and disfigured for life; and for every one that conquered another had fallen never to rise again. There was, indeed, a second Kilmarnock under the green sod of the kirkyard. The Kilmarnock which had reason to dread the epidemic's approach was a Kilmarnock the least able to meet it. It consisted of a band of little children, numbering less than 500 in all."

The experience of Kilmarnock is borne out by records kept in other places, and the question is seen to be one of exceptional interest when the altered behaviour of small-pox in comparatively recent years is studied in connection with it. McVail has referred to this subject in commenting upon the annexed table of statistics relating to small-pox in Geneva (1580–1760), Kilmarnock (1728–64), and London (1848–51). The table appeared in the Report of the Medical Officer of the Local Government Board for 1884.

Contributions of Various Ages to 1,000 Small-pox Deaths at All Ages.

Ages at death.	Geneva (1580-1760).	Kilmarnock (1728-64).	London (1848-51).	London, 1884.		
				Unvaccinated community.	Vaccinated community.	Total Inhabitants.
0–10	961	988	815	612	86	343
10–20	26½	5	59	146	173	170
20–30	10	7	83	108	319	213
30–40	2½	—	32	72	221	142
40 and upwards .		—	11	62	201	132
Total . . .	1,000	1,000	1,000	1,000	1,000	1,000

McVail remarks—" These figures show : (1) That when vaccination was unknown, from 96 to 99 per cent. of all small-pox deaths in Geneva and Kilmarnock occurred under 10 years of age—that, indeed, small-pox was in such places a disease of childhood. (2) That in London in 1848–51, when vaccination was partially in vogue, without being enforced by law, 80 per cent. of the victims were under this age. (3) That in London, in 1884, under general vaccination, only 34 per cent. of the total small-pox deaths were under 10 years. (4) That among the vaccinated community of London less than 9 per cent. ; while among the unvaccinated community 61 per cent. were under 10 years. Thus we find that with the spread of vaccination, children, as a whole, and especially vaccinated children, bear less and less of the total small-pox mortality, while among the unvaccinated the distribution approaches more nearly to that of pre-vaccination times."

In the case of scarlet fever it was appreciated by Netten Radcliffe more than sixty years ago that the crowded courts of the great towns were the chief foci of infection, and the attempt was made to control the ravages of epidemics by hospital isolation, disinfection, etc., with a very large measure of success. In the poorer urban areas young children are still more especially attacked, thus acquiring protection. Recent inquiry, for example, has shown that, in London, the poorest children, who have been already immunised, suffer distinctly less at the school ages than children attending the best elementary schools ; whilst these latter children, in their turn, are attacked on an average at an earlier age than the children of the well-to-do. In diphtheria the problem is more complicated. Dowson, in his study of " Diphtheria in older and newer Bristol," first suggested that movement of population from rural to urban areas was here in question, and this surmise is amply confirmed by later inquiries.

When a patient is attacked by disease and recovers, the mere fact of his recovery suggests that some altered condition of body has been induced, in the course of the malady, which renders him, at any rate for the time being, able to resist the disease. This consideration was brought into prominence with the development of the germ theory of disease, and Pasteur, applying to the phenomena of infectious disease the facts learnt concerning the behaviour of micro-organisms in culture fluids, propounded an " hypothesis of exhaustion " as an explanation of the reason why protection was afforded. According to this theory, the organisms causing disease, or the attenuated organisms employed for bringing about a condition of protection against the disease, use up certain constituents of the body necessary for their own growth and development. This hypothesis fails to explain many of the phenomena of immunity, and it was thrown a good deal into the background with the growth of the belief that the multiplication of living organisms in the body is not necessary for the production of protection.

Another hypothesis, the theory of "retention," had, however, been propounded as an alternative to Pasteur's hypothesis. This hypothesis assumed that organisms growing in the body produce substances inimical to their further development, and so promote recovery from disease, and (as long as the inimical substances are retained in the body) a condition of protection against future attacks of the disease. The theory seems to be supported by the phenomena observed in connection with inoculation of toxins. But there are difficulties in connection with this hypothesis also—it is hard to understand how toxins can be retained for long periods in the body, and, in point of fact, observation shows they are speedily eliminated. Again, the tissue juices of protected animals are, as a rule, capable of acting as media in which the organism, concerned in causing the disease, can be cultivated. The retention hypothesis, too, has thus of late years become discredited. It is now fully appreciated that the problems of immunity are not to be explained by such simple hypotheses as these.

One result of recent knowledge has been to bring into prominence certain distinctions between the condition of immunity to disease which is " natural " or " innate " on the one hand, and that which is " acquired " or " artificially induced " on the other. Instances of natural immunity are the insusceptibility of the human species to cattle plague, fowl cholera, swine erysipelas, and other diseases which effect animals, the insusceptibility of animals to measles, whooping-cough, gonorrhœa, etc., and the relative insusceptibility of the dog, frog, rat, and the Algerian sheep to anthrax. As examples of acquired, artificially induced, or, as it is sometimes termed, specific immunity, may be mentioned the protection against subsequent attack manifested after recovery from particular diseases, and the condition of protection produced by certain kinds of specific treatment.

Natural Immunity—The causes of natural immunity have been sought, of late years, in part in the ability of fixed and wandering cells to engulf and destroy bacteria and intruding matter foreign to the body (phagocyte theory), and in part in the bactericidal properties of the body fluids. Metchnikoff, in 1884, first drew attention to the power exhibited by the leucocytes of daphnia (a water flea) of enveloping and destroying the spores of a fungus, which causes a diseased condition in this animal. He afterwards described the phenomena of phagocytosis as occurring in frogs infected with anthrax, and particularly laid emphasis upon the degenerative processes which affect the anthrax bacilli within the leucocytes of the frog. He was led to the conclusion that this phenomenon was especially manifested in the case of resistant animals, and that the likelihood of an animal being able to resist a particular form of disease could be predicted by noting the extent to which phagocytosis occurred. Much controversy arose with regard to the generalisations of Metchnikoff, and not a few phenomena difficult of explanation on his hypothesis were observed. An important point was, however, noted, in connection with these investigations, as to the behaviour of invading organisms in relation to cells. It was found that introduction of disease germs in particular situations was followed by migration of leucocytes and by inflammatory reaction. The migration was presumed to be due to the influence of attraction exerted by certain chemical substances, and was termed "positive chemiotaxis"; in other instances chemical substances were found to exert a repellent influence, "negative chemiotaxis." The phagocyte theory has been seen to need re-examination in the light of study of the action of bacterial toxins, and it is probable that in many instances the phenomena of phagocytosis are to be regarded as an after effect and not as the cause of the production of immunity.

The rival theory to the phagocytic, or "cellular" theory of Metchnikoff, assumes that the body fluids are mainly operative in destroying invading bacteria. Freshly drawn blood, pericardial fluid, and cell-free serum have been found to possess marked bactericidal properties. This power is lost on heating to 55° C. Buchner showed that the destructive power of these fluids was due to contained protective substances, "alexins" as he termed them (from a Greek word signifying to protect). The fact that withdrawal of the mineral salts from serum deprives it of its protective properties, while, furthermore, the salts alone cannot be regarded as operative (inasmuch as in that case the destructive powers of the serum should not be abolished by heating to 55° C.), suggested that the alexins were proteid-like substances in loose combination with salts. It has been shown that the protective bodies can be precipitated with the proteins from serum, and, after drying, again dissolved and shown to retain their activity.

Neither the phagocytic or "cellular" nor the alexin or "humoral" theory seems capable of explaining all the facts as to natural immunity. It has been suggested that there is a *via media*, and that the phagocytes produce the alexins. By injection of a sterilised emulsion of wheat gluten into the pleural cavity of rabbits and dogs an exudation containing leucocytes in abundance and possessing pronounced bactericidal properties is obtained. It has been argued that these powers cannot be attributed to the leucocytes, as they are still manifested after freezing and thawing, and that they must therefore be due to substances (alexins) which have been added to the exudation by the leucocytes.

The phenomena observed as regards behaviour of leucocytes, towards foreign material introduced into the body, have suggested that in order to increase the natural power of resistance to bacteria, "hyperleucocytosis" should be induced. Koch's original tuberculin has been supposed to act by bringing about accumulation of leucocytes in the diseased tissues, and thus favouring destruction of the tubercle bacilli present in them. The production of chronic venous congestion has hence been advocated in the treatment of tuberculous disease of joints and bones with the idea of promoting local increase of resistance.

Apart from power of dealing with invading micro-organisms there may be a natural resistance to certain poisons. The ichneumon and many snakes are unaffected by snake venom, and scorpions are said to be immune against their own poison. Poisons which are fatal when injected may be comparatively harmless when swallowed. Hence the success, in some instances, of the practice of sucking poisoned wounds. In the case of snake venom, it has been stated that the saliva itself possesses a definite anti-toxic action.

Specific or Acquired Immunity may result from an attack of specific disease or from the production of one of the two states which Ehrlich distinguished as active and passive immunity. The former condition is brought about by protective inoculation, the specific immunising substances being generated in the body itself; the latter is induced by introduction of protective substances, the development of which has been accomplished in the serum of some other animal.

As examples of immunity produced by an actual attack of disease, the protection afforded by small-pox, scarlet fever, measles, and whooping-cough, and perhaps in less degree by typhoid fever and plague, among human diseases may be mentioned—cattle plague, pleuro-pneumonia, etc., among animal diseases, may also be referred to. Some infectious diseases appear to afford little or no protection against subsequent invasion, or the protection is only very transitory, while in the case of pneumonia and erysipelas one attack of the disease seems to render the sufferer even more liable than before to future attacks. The possible influence of mild, unrecognised forms of disease has to be kept in mind, and the fact that certain diseases such as malaria, yellow fever, and typhoid fever, not infrequently attack new-comers in a particular locality, and fail to affect to a like extent persons long resident in the place, may perhaps be thus explained. The production of immunity by the "active" method, *i.e.*, by inducing the formation of specific protective substances in the body itself, involves, as a rule, the setting up of some febrile reaction, and further a period of delay must inevitably intervene before the formation in the body of the protective substance is accomplished. On the other hand, the immunity, when successfully induced, is usually of a more or less lasting character, while in that produced by the "passive" method, the protective substance may be rapidly excreted, and the immunity prove thus of a merely transitory nature.

The active method of producing immunity has been practised—

(*a*) *By inoculation with living virulent virus*, *e.g.*, in small-pox inoculation in man, and in pleuro-pneumonia inoculation in cattle.

(*b*) *By inoculation with living but attenuated virus.* This method was first employed by Pasteur in the case of fowl cholera, by use of cultures which had been attenuated by exposure to the air. The attenuation has since been effected in the case of anthrax and rauschbrand by application of heat. Anthrax inoculation by Pasteur's method has been somewhat extensively employed on the Continent, but the protection afforded has been found not to be of lasting character. In swine erysipelas attenuation has been produced by passage of the virus through comparatively insusceptible animals, and this method, it may be noted, is that which is operative in vaccination against small-pox, human variola and cow-pox being really one and the same disease. In Pasteur's prophylactic treatment of rabies attenuation is effected by drying the spinal cords of rabbits, and the material thus obtained is used as vaccine. This form of treatment has been attended with marked success, but, as the process of producing immunity takes time, its commencement must not be too long delayed. Lastly, attenuation may be brought about by the addition of antiseptics.

(*c*) *By inoculation of cultures, the organisms in which have been destroyed.* This method has been particularly tried in connection with cholera, typhoid fever, and plague. As regards the first-named disease, R. Pfeiffer showed that guinea-pigs could be immunised by injection of cultures containing living or dead cholera organisms. He found that living organisms, on being introduced into the peritoneal cavity of such immunised animals, were rendered incapable of exhibiting motility; moreover, after a few minutes, the vibrios became swollen and were broken up, and finally dissolved. The like reaction (" Pfeiffer's phenomena ") was exhibited when anti-cholera serum, which had been heated to 58° C., and thus deprived of bactericidal power *in vitro,* was mixed with vibrios and injected into the peritoneal cavity of a normal guinea-pig. The reaction is a " specific " one, only true cholera vibrios being affected in this way, and the " bacteriolysis " induced has therefore been attributed to a " specific bactericidal " substance which, it is presumed, has been generated in the body of the immune guinea-pig, and is present in the serum of the immunised patient. It was later found that perfectly fresh immune serum was by itself capable of producing Pfeiffer's phenomenon *in vitro*; such serum was liable to become inactive, but could be " activated " by addition of a small quantity of normal serum. Hence, it was argued, two factors were at work; there must be present a specific thermostable " immune body," and, in addition, an eminently unstable thermolabile ferment-like " complement " or " alexin," which is only present in minute quantities in the serum, but is capable of being elaborated by living cells.

The subject has been further investigated in connection with the " laking " of blood. Active serum, capable of producing laking of particular kinds of blood, can be obtained by injection of the blood of one animal into another animal. Thus Bordet injected defibrinated rabbits' blood into guinea-pigs, and found that the serum of the latter then possessed hæmolytic properties, *i.e.*, it was capable of laking rabbit's blood corpuscles. This serum was rendered inactive by heating to 55° C., but could be " activated " by addition of normal guinea-pig's serum.

Gruber and Durham, starting from the observation that cholera vibrios on being brought in contact with cholera-immune serum in a test-tube lost their motility, and adhered and collected into clumps, studied further this " agglutination," which they attributed to the presence of specific protective substances. They found that care was needed in drawing conclusions with regard to this test; a cholera-immune serum was able also to agglutinate other allied organisms, but the reaction, in the case of the specific organism, was still marked, even when the serum was greatly diluted. Similar phenomena were observed when the typhoid fever bacillus and some other organisms were made the subject of experiment.

Typhoid immune serum sometimes agglutinates *Bacillus coli* and the bacillus of Gärtner, but only when the serum is in sufficient strength, the phenomenon being, on the other hand, produced, in the case of the true typhoid fever bacillus, even when the serum is much diluted. Widal advanced matters a step further when he showed that enteric fever bacilli were agglutinated by serum obtained from cases of enteric fever even before the end of the first week. This discovery of the fact that the characteristic reaction occurred after the lapse of a few days only from the date of attack, afforded a most valuable means of detecting the existence of typhoid fever, and in doubtful cases of illness this " Widal reaction " has been extensively employed for clearing up the diagnosis.

For the production of immunisation against typhoid fever, Wright employed cultures of Eberth's bacillus, after first sterilising them by application of heat. Injection of an appropriate dose of sterilised culture produces transient febrile disturbance, with headache and malaise, the site of inoculation becomes tender, and the nearest lymphatic glands are rendered painful on pressure. The blood a few days later may agglutinate the specific bacilli. The toxicity of typhoid vaccines has been reduced appreciably in recent years by improvements in the mode of preparation. Castellani introduced the method of employing polyvalent vaccine, and during the War large use was made of such vaccine against typhoid and paratyphoid A and paratyphoid B. Moreover, careful attention was given to the question of standardisation.[1]

In the case of plague certain animals have been rendered immune by the active process, and serum obtained in this way (Yersin's, Lustig's, etc., serum) had been employed for inoculation in the human subject. Haffkine introduced in 1897 a modified method by treatment with killed plague cultures. Specially prepared broth cultures of plague bacilli, from two to six weeks old, were heated to 65° C. for an hour ; a small amount of carbolic acid was then added, and the vaccine was decanted and bottled, with suitable precautions. It was intended that the first injection of " prophylactic " should be followed by a second injection after eight or ten days. In the report of the Indian Plague Commission (vol. v., 1901) it is stated that " inoculation sensibly diminishes the incidence of plague attacks on the inoculated population, but the protection which is afforded against attacks is not absolute." Again, " inoculation diminishes the death-rate among the inoculated population."

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[1] Besredka has contended that in animals, especially when some method of intestinal sensitisation is induced, as by ox bile, the ingestion by the mouth of killed cultures of typhoid and paratyphoid sets up a complete protection against the natural infection without a trace of antibody in its blood. With dysentery bacilli the same protection is produced without any preliminary sensitisation.

(*d*) *By inoculation with material derived from bacterial cells.*

Such material has been obtained by various methods. In the preparation of the original tuberculin of Koch and in that of mallein, cultures in glycerine broth were concentrated by evaporation, and the substances, mainly proteins, thus extracted were subsequently purified by precipitation with alcohol. Koch's tuberculin undoubtedly sets up remarkable local changes in parts of the body affected with tubercular mischief. The condition of hyperæmia and reaction induced was thought of as being likely to bring about cure of the disease; the failure of the remedy to realise anticipations formed with regard to it, has been attributed to the fact that, in cases of tubercular mischief, it is not only the tubercle bacillus that has to be contended against, inasmuch as streptococci and other organisms are also present in the diseased tissues; this is the reason, it is said, why tuberculin has been found not to produce good results. Tuberculin has, however, been largely employed with great success as a diagnostic agent in cattle. At first the test was found unreliable, but increase in knowledge, as to the conditions which should be observed in employing it, has led to the attainment of very precise results. Mallein, made from cultures of glanders bacilli, by a similar process to that adopted in the preparation of tuberculin from tubercle bacilli, has been employed as a diagnostic agent in cases of suspected glanders. A later method employed by Koch for the manufacture of his tuberculin (T. R.) was introduced in 1897. In this method the bacilli are dried, powdered, and extracted with distilled water; the residue ("rest," whence the name T. R., "tuberculin rest") is again subjected to similar treatment to that already mentioned. Koch obtained with this new tuberculin favourable results with regard to immunisation and cure of animals, but the remedy has not been found satisfactory in the case of tuberculosis in man. The aim in recent work has been to obtain a vaccine which, while possessing immunising influence, is as far as possible devoid of toxic action.

(*e*) *By injection of toxin.*

The fact that immunity can be brought about by injection of filtered cultures was first demonstrated in 1886 by Salmon and Smith, in the case of hog cholera, and similar results were later obtained in other forms of disease. The method, however, attained special prominence in connection with development of knowledge concerning the specific toxins of diphtheria and tetanus, and particularly after the discovery was made by Behring in 1890, that the serum of an animal immunised by repeated injection of toxin possesses definite antitoxic properties. This discovery opened up a new field of inquiry, leading, as it did, to the production of immunity by the passive method and to study of the whole question of serum therapeutics.

The passive method of producing immunity—Antitoxic serum was first obtained, in the case of diphtheria, by Behring in 1890. Behring and Kitasato shortly afterwards showed that analogous phenomena were demonstrable as regards tetanus. Ehrlich and others obtained similar results by inoculation of vegetable toxins, ricin, abrin, and robin. Calmette endeavoured to apply antitoxic treatment to snake-poisoning. He found that to a certain extent antitoxic action could be produced ; a serum protecting against one kind of venom was, however, also protective against other kinds, and thus the antitoxin is not specific in the same sense as in the cases of diphtheria and tetanus. No success has hitherto attended the attempt to apply antitoxic treatment in tuberculosis. In cattle plague the use of bile, and that of serum and infected blood, have been tried. The nature of the immunity produced in the former case is uncertain ; in the latter a true antitoxic serum appears to have been obtained. In tetanus no good result is yielded unless the antitoxin is used quite early.

In diphtheria, however, antitoxic treatment has produced unmistakably beneficial results. (See p. 418.)

The serum used is an antitoxic serum. It inhibits the action of toxin, and thus gives opportunity for the natural powers of resistance of the body to come into play. It may be noted that in both diphtheria and tetanus the development of the bacilli is mainly local, and that it is the toxins produced which gain access to the general circulation, and cause the main symptoms of illness. The fact that toxic diseases, as distinguished from what are sometimes called septicæmic diseases (in which the organisms invade the blood), are in question, may explain why it is that, in the case of diphtheria and tetanus, antitoxic treatment has been successful.

Diphtheria antitoxin is obtained, according to Behring's method, by inoculating horses with toxin of progressively increasing strength. At first carbolised cultures, to which iodine terchloride has been added, are used ; ultimately toxin, the virulence of which is unattenuated, is employed. Horses bear the treatment well, and serum is readily obtainable from them. The immunisation value of the serum obtained requires to be carefully estimated. According to the original method of Behring, a normal toxin, ·01 c.c. of which will kill a guinea-pig of 250 to 300 grammes weight within five days, is prepared, and the serum is standardised against this. If ·1 c.c. of serum neutralises 1 c.c. of normal toxin, then each c.c. of serum is said to contain one immunisation unit.

Supersensitisation, Anaphylaxis, Allergie—These are the various names given to the paradoxical condition in which an immunised individual is found to be highly sensitive to quite a small dose of the infective agent. In ordinary " serum disease " (which is due to the horse serum and not to the antitoxin) the rashes, joint pains, pyrexia, etc., never appear before the seventh day. In anaphylaxis, however, the symptoms are developed within a few hours or up to the fifth day. A somewhat similar condition is that observed in small-pox revaccinations, which " take " and run their course much more quickly than a primary vaccination does. Again the specific tuberculin and diphtheria tests are analogous phenomena. Anaphylactic shock in the human subject is only very rarely fatal. It is apt to supervene if the second infection follow after an interval (from the first infection) of twelve days or more.

Hypotheses of Ehrlich and others in regard to Immunity—There has been much speculation as to the mode of production of antitoxin, and as to the cause of its antagonism to toxin. With regard to the latter, the action, it was said, could not be explained on the supposition that antitoxin is a mere chemical antidote to toxin, for the reason that discrepancies are apt to be observed in the quantitative results obtained, and a mixture of the two substances, which is neutral when tested on one kind of animal, may produce fatal disease in another species. It was therefore suggested by Roux that the antitoxin acted upon the living cells of the body, rendering them immune to toxin, and producing a physiological as opposed to a chemical neutralisation.

Ehrlich, however, from his experiments with ricin, concluded that as the reaction between toxin and antitoxin was accentuated and diminished by the factors which bring about similar modifications in chemical reactions (warmth accelerating, cold retarding, and the reaction being more rapid in concentrated than in dilute solutions), it was essentially of the same nature. He explained the observed fact that varying amounts of toxin bouillon are neutralised by one immunity unit of antitoxin, on the hypothesis that the toxin contains two constituents, or combined groups, the one very stable, the other unstable. The affinity of the toxin for antitoxin is dependent on the former or " haptophore " group (from a Greek word meaning to fasten on or to fix) ; the unstable group is styled " toxophore." In 1897 he was led to announce the " Seitenkette," or " Side-chain " theory, in explanation of the phenomena of antitoxin formation. He concluded that antitoxin was the substance, entering into the composition of certain kinds of protoplasm, which caused the cells containing it to be susceptible to the action of toxin. This substance, he argued, does not enter into the composition of the functioning centre of the cell, but is an attached " side-chain " of atoms—the term being adopted from the nomenclature of organic chemistry. The side-chains he held to be normally nutritive in function, attaching to themselves food-stuffs important in the cell economy ; but they might incidentally be " toxophile." The idea that they are specially designed to seize upon toxins could not, of course, be entertained ;

it would be superfluous, as Ehrlich remarks, to suppose that "all our native animals possess in their tissues atomic groups deliberately adapted to unite with abrin, ricin, and crotin, substances coming from the far distant tropics"; but by chance, as it were, these toxophile groups may possess the capacity of anchoring themselves to this or that toxin. Ehrlich noted a distinction between toxins related to proteins—which it is not surprising, therefore, should possess a haptophore group corresponding to that of a food-stuff, and alkaloids and other poisons in connection with which similar phenomena have not been observed. The fixation, whether it be of normal food-stuff or of toxin, was, however, he maintained, of a specific character; Ehrlich suggested the analogy of the male and female screw, or of lock and key, as throwing light on the manner of adaptation to one another of the groups of atoms in the side-chains and in the haptophorous constituents of toxin. Ehrlich sought to explain development of antitoxin in the blood by appealing to Weigert's physiological "Law of over compensation"—the anchoring of toxin to side-chains of susceptible cells and the resulting destruction of these side-chains leading to their being reproduced by the cell protoplasm in excess and then being transferred to and accumulating in the general circulation. A condition of immunity results, for the side-chains "anchor" any haptophorous groups of the toxin which may be introduced into the blood, and the groups so anchored are deprived of any opportunity of obtaining access to susceptible cell-protoplasm (Croonian Lecture "On Immunity with Special Reference to Cell Life," "Proc. of Royal Society," vol. lxvi., No. 432). Wassermann has shown that tetanus poison can be anchored to the brain substance of guinea-pigs, by demonstrating that on mixing the toxin with broken-down, fresh guinea-pig's brain-substance, the surrounding fluid is toxin-free, while the brain charged with toxin has also lost all poisonous property.

The "Seitenkette" theory serves to explain many of the phenomena of antitoxin production.

As soon, however, as the attempt was made to standardise toxins and antitoxins difficulties became apparent, and Ehrlich was compelled to assume the existence of other substances, "toxoids," "toxones," etc., in order to explain anomalous results. Moreover, on applying his theory to account for the action of sera possessing *antimicrobic* as opposed to *antitoxic* properties the phenomena were seen to be even more complex. Ehrlich tried, nevertheless, to adapt his theory so as to explain the behaviour of the "bacteriolysins" which break up bacteria, the "coagulins" which cause precipitation of albuminous bodies, the "agglutinins," and the "antiferments" and "cytotoxins."

In illustration of the difficulties experienced, Ehrlich had assumed that the "immune body" (or "amboceptor") was a necessary link between an affected cell and the complement. According to him the cell, by means of a special "receptor" process, attached the immune body to itself and the immune body in its turn "anchored" the complement. It had already been found, however, by Pfeiffer, in 1895, that in some instances a large amount of immune serum (introduced intraperitoneally) might not protect an animal, while a smaller quantity was effective in doing so. Then, in 1901, Neisser and Wechsberg demonstrated a similar paradoxical phenomenon *in vitro*. This result was ascribed, under Ehrlich's scheme, to an excess of amboceptors, which united both with receptors and complement and prevented the receptors combining with the amboceptor-complement groups. Later work throws doubt upon the validity of this explanation and suggests that the phenomenon is an outcome of the colloid nature of the reacting substances.

Ehrlich, however, continued to maintain that toxin neutralises antitoxin much as a strong base neutralises a strong acid; and further held insistently by his scheme of receptors. Arrhenius and Madsen, on the other hand, put forward the view that the chemical law of mass action applies to the toxin-antitoxin reaction. A third hypothesis was exploited by Bordet and Craw to the effect that the reaction is an "adsorption phenomena," analogous to the action of a dye upon a tissue. Thus, when filter paper is stained with Congo red, if the paper be placed straightway in the dye it is uniformly stained, but if pieces of filter paper are added at intervals the first piece takes up most of the dye and the later pieces remain comparatively colourless. A similar phenomenon, the "Danysz effect," is observed when toxin is added to antitoxin, and this fact strongly suggests that adsorption is here also in question.

Ehrlich, nevertheless, still maintained that the various "antibodies" represent nutritive side-chains, which have been developed in excess and pushed off into the circulation. "In this manner," he said, "is simply and naturally explained the astonishingly specialised arrangement that, through the introduction of a definite bacterium into the body, something is produced which is endowed with the power of destroying, by solution, the bacterium which was administered and no other."

Of late years the disposition to explain many of the phenomena encountered as being due to the colloid nature of the substances concerned has steadily grown. The "zone phenomenon," for example, observed in agglutination is a case in point. It is found that under some conditions it is only when the proportions of the interacting colloids are within a certain range or zone that precipitation results, and the analogy here with the paradoxical zones of inhibition in agglutination is strikingly suggestive.

The use of immunity tests as an aid in diagnosis, meanwhile, has come to assume more and more importance. Agglutination, first brought into notice in 1896, led the way ; the tuberculin cutaneous reaction and the Calmette oculo-reaction were introduced in 1907 ; the Schick intracutaneous test for diphtheria was brought forward in 1913. Tests based upon " fixation of complement " had followed upon the discovery of the Bordet-Gengou phenomenon in 1901 ; and they were extensively used in the case of organisms of the typhoid group and in cerebro-spinal and gonococcal infections. The Wassermann test (1907) was at first supposed in like manner to be a strictly specific test, the antigen employed being originally derived from a syphilitic liver. It is now, however, usual to employ as antigen an alcoholic extract of normal liver, or heart muscle, often with the addition of cholesterin.

CHAPTER IX

INFECTIOUS DISEASES

Actinomycosis—The history of this disease may be said to date from 1876, when attention was first drawn, by Bollinger, to its occurrence in cattle. In 1877, Israel described the disease in man; in 1878, the parasite concerned was named by Harz, the actinomyces or "ray fungus."

It has since been found that cultures from various sources present considerable differences, and that the term "actinomycosis" represents a group of the infections in which the parasite forms granules. Most of these infections are caused by a streptothrix, but the common form of actinomycosis in the ox is due to a bacillus—the actinobacillus; only one case of human infection with this bacillus is on record.

The malady is by no means a new one, as is made clear from accounts of earlier date of "wooden tongue." Cattle are said to be often affected in Austria, Germany, Italy, Russia and North America; in some abattoirs on the Continent the disease has been found in one form or another in as large a proportion as 2 per cent. of the cattle slaughtered. In England in certain herds an appreciable percentage of the animals proved on examination to be affected. Swine and horses are occasionally attacked. In man the disease is far less common.

The malady is inoculable, but does not, as a rule, spread from one animal to another. The mammary gland is occasionally involved, and it has been thought that milk might serve as the medium of infection, but there is no evidence that this is the case. Bostroem isolated from several cases an aerobic streptothrix, easily grown at air temperature, more or less akin to the mycelial parasites which affect grasses.

It has been suggested that contaminated grasses constitute a possible source of mischief, and it has been stated that if grain be inoculated, the plant which develops is infected with actinomyces, and the sharp awns of barley, etc., if contaminated, on being eaten by an animal, would be specially likely to convey infection, by scratching or penetrating the mucous membrane of the alimentary tract. This theory is supported by the fact that material recognisable as being of vegetable origin has been found within actinomycotic growths.

Again, the majority of the recorded cases have occurred in farmers, labourers, grooms, millers, and others, who by the nature of their work have been brought in contact with hay, straw or grain.

A rival theory is that the disease is due to an organism inhabiting the mouth, and found especially in connection with carious teeth, which in association with certain factors, one of which is the presence of a foreign body, is able to invade the tissues. This view is supported by the fact that the most common organism associated with clinically typical actinomycosis is the anaerobic mycelium of Wolff and Israel growing best at body temperature.

The habit of chewing grain or straw has been noted in sufferers ; inoculation through a decayed tooth is held to be the usual mode of infection. Baracz in 1889 recorded an instance in which the disease was passed from man to wife by kissing. In a few cases in which the skin was primarily involved the circumstances have pointed to previous inoculation of a cut.

Actinomycosis runs a chronic course, and its nature is apt to be overlooked ; the case may be regarded as one of tuberculous disease of the jaw (other bones may be the seat of mischief, but the lower jaw is involved in the majority of instances), or of chronic abscess or "tumour" (in the liver or other viscera) or of peritonitis, empyema, or pulmonary tuberculosis. In cattle the tongue is specially affected. On careful examination of material from an actinomycotic growth, minute yellow granules can, as a rule, be detected, and if one of these be squeezed out, stained, and examined under the microscope, the arrangement of the fungus as a mycelial network, from which radiate filaments possessing characteristic club-shaped peripheral extremities, can be demonstrated. The grains can be transplanted and cultures made, glycerine-agar being specially adapted for the purpose. In artificial media the "clubs" are not, as a rule, found.

The variety of Mycetoma or Madura foot with pale granules is caused by a streptothrix and probably also by a hyphomycete, the variety with black grains by a hyphomycete.

Anthrax—Outbreaks of this disease affect sheep, cattle, swine, horses, camels, deer and goats, and occasionally occur in man. The malady was found to prevail in this country in 1891 among deer. Little was accurately known concerning anthrax until the end of the eighteenth century, when it was found that it occasionally occurred in men who had been engaged in the manipulation of hair, wool, etc. In 1849 the anthrax organism was first observed by Pollender, and Davaine, some years later, showed that the bacillus was the actual cause of the disease. In 1876 and subsequent years, Koch greatly extended knowledge coucerning the life-history of the organism. In 1863 deaths begin to appear in the Registrar-General's returns under the heading "malignant pustule." Since 1881 all anthrax deaths in those returns are classed as instances of "splenic fever" (anthrax), and their number has varied from zero to six annually.

In cattle the disease is generally called "splenic fever"; marked enlargement of the spleen is a conspicuous feature of the malady. On the Continent outbreaks in cattle have been frequently observed —in France, Germany, Russia, and Italy,—and accounts of anthrax prevalence among lower animals have been forthcoming from Persia, India, Siberia, China, and parts of Africa and North and South America. Animals appear to acquire the disease, as a rule, by infection from the alimentary tract, possibly also by inhalation; the infective property seems to be imparted to fields and pastures by contamination with the bloody excretions from the mouth, nose and bowel of infected animals or with waste water from tanyards dealing with infected hides; it is said that the danger, incidental to grazing upon such pastures, is particularly great when the surface soil has become thoroughly warmed, and when certain conditions as regards moisture obtain. Pasteur thought it likely that spores were brought to the surface by earth-worms, but it has been shown that spores are not formed when the carcasses of infected animals are buried without being opened.

The precise part played by flies in the spread of anthrax has not been ascertained, but this mode of spread would certainly seem possible.

Flies feeding on blood containing anthrax bacilli can carry and distribute these bacilli in a virulent state for several days; opportunities for infecting themselves from the bloody discharges of diseased animals must often occur. In flies which become infected with anthrax spores and die of empusa disease or cold, the spores remain alive and fully virulent in their bodies, if kept dry in bottles for years. Infected dead flies might easily be a source of infection.

Anthrax spores ingested by the larvæ are present in the flies which develop from them.

The Board of Agriculture has compiled, since 1887, returns showing the number of anthrax outbreaks affecting cattle, sheep, swine, and (since 1893) horses in the counties of Great Britain. In 1887, 236 outbreaks (636 animals attacked) occurred, and the numbers have fairly steadily augmented until, in 1909, 1,317 outbreaks were reported. The increase is doubtless due, in the main, rather to greater accuracy of diagnosis than to more extended prevalence of the malady.

Pasteur in France, Sclavo in Italy, and Sobernheim in Germany, have practised, with success, methods for immunising animals against anthrax. In man the infection may enter the skin (malignant pustule) by contact with infected material; or the lungs (woolsorter's disease) by inhalation of spores during the handling of skins, or working with horsehair, wool, etc., when the symptoms resemble those of pneumonia; or, more rarely, infection may enter the digestive tract, through the ingestion of meat of an animal affected with the disease.

Numbers of samples of dust in factories have been found to contain anthrax bacilli. But it is evident that internal anthrax can be contracted in the atmosphere of the combing-room of a factory which is free from dust in the ordinary sense of the word. After the introduction of particular wools into the Yorkshire mills, notably mohair and alpaca, a number of deaths from "woolsorter's disease" occurred, which was fully investigated in 1880 by Spear, and shown to be really "internal anthrax." From 1896–1917 inclusive, 56 cases of internal anthrax occurred in the woollen industries; all except one were fatal. Malignant pustule, however, occurs even more commonly among wool-workers: 537 cases were notified in the same period: 58 of the patients died. The disease also occurs among persons who manipulate hair and among brush-makers. On tabulating the recorded cases of human anthrax in London and its neighbourhood between 1873 and 1896, it transpired that 148 cases of the disease had been recognised during those years; of these 108 occurred among persons engaged in the hide and skin trade, 5 among persons engaged in slaughtering animals, 18 in connection with the manipulation of horsehair or the manufacture of brushes, 1 case occurred in an individual employed in a bacteriological laboratory, and 16 cases under circumstances in which the source of infection was not traceable.

In 1895, cases of anthrax contracted in any factory or workshop were made compulsorily notifiable to H.M. Chief Inspector of Factories. In the years 1910–21, 443 cases were due to wool, 198 to hides and skins and 66 to hair and bristles. The number of cases reported in successive quinquennial periods has increased from 56 in 1896–1900 to 164 in 1911–15, and in the two following years 145 cases were recorded. The increase in the later years probably represents greater accuracy in notification rather than growing prevalence of disease. It is noteworthy that in several of the cases reported in London since 1901, persons who have manipulated goat-skins have suffered, and there is a remarkable tendency for such attacks (and the same thing has been observed in cases associated with horsehair, and with hides) to occur in groups, and in connection with the manipulation of particular consignments of goods.

In 1916 several cases were traced to the use of shaving brushes from Japan made from mixed hair of Chinese origin. Further implication of shaving brushes has since occurred from time to time. Careful study of the origin of infecting material is obviously, therefore, necessary, and special precautions should be taken in all instances in which material from a source which is under suspicion has to be manipulated. If the products dealt with present any unusual appearance, suggestive of the fact that "dead hides" or specially contaminated horsehair, etc., possibly containing anthrax spores, are in question, the need for such precautions is particularly obvious.

In 1913 the Home Office appointed a Departmental Committee on Anthrax in the Woollen Industry, and a Disinfection Subcommittee, of this Committee, reported in June, 1918, advising that every dangerous variety of material should be disinfected in central disinfecting stations, at the earliest possible stage in the course of transfer from the producing to the consuming areas. In the case of such material, risk of infection could not be controlled by regulations to be applied *in factories.* As the outcome of this report the Prevention of Anthrax Act, 1919, was passed.

A Government Wool Disinfecting Station has been established at Love Lane, Liverpool, where the material is dealt with in automatic apparatus, so as to do away with any need for handling.

All wool and animal hair imported from or through Egypt, and all East Indian goat-hair are required by Order in Council to be disinfected. Other material is sent voluntarily to the station. After washing with warm dilute alkaline solutions, it is subjected to disinfection in baths of warm formaldehyde.[1] The Departmental Committee stated that disinfection of wool and hair ought not to be regarded as permanently necessary. The true solution is the prevention of anthrax among animals, and the destruction of the comparatively few which may die from the disease even when the most careful precautions are taken.

The former Rules of 1899 are now replaced by the Hides and Skins Regulations, 1921 ; hides are best steeped in a bath of hydrochloric acid (2 per cent.) and common salt (10 per cent.)—Schattenfroh's method.

Complete sterilisation of shaving brushes is impracticable, the difficulty being to destroy the anthrax spores embedded in the handle of the brush.

The Anthrax Order of 1910, issued by the Board of Agriculture, directs that the carcasses of diseased or suspected animals shall be buried, unopened, in lime, at a depth of not less than six feet below the surface, or else destroyed by exposure to a high temperature or to chemical agents, in a place approved for the purpose by the Board. Precautions to be adopted in relation to infected dung, litter, etc., and with regard to preventing contamination by excretions, blood, etc., are also specified in this Order.

Animals known to have been in contact with the diseased animal are to be detained until found free of the disease.

The Board emphasize the value of the bacteriological examination of blood or smears from the cut surface of lymphatic glands. In a leaflet issued, stockowners are invited to report to the police every case of sudden or unexpected illness or death in their stock, especially among cattle. Butchers, slaughterers, and knackers are warned not to shed the blood, or dress the carcass, of such an animal.

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[1] For details of procedure, see Home Office Report on first year's working, quoted "Lancet," Dec. 16, 1922, p. 1295.

Cerebro-spinal Fever (*Epidemic Cerebro-spinal Meningitis*)—Hirsch described four periods of special prevalence of cerebro-spinal fever as follows—1805–15, 1837–50, 1854–75, and 1876–86; to these there must now be added 1893–1900 and 1906–16. These periods stand in curious relationship to the dates 1803, 1833, 1847, 1874, 1890, and 1918 of the great influenza pandemics. The prevalences of cerebro-spinal fever may follow or lead up to the influenza, epidemics; as Newman in the Report on the Pandemic of Influenza 1918–19, observes, " There is a development over a series of years of various clinical forms of infections which tend to assume a generic type and to prevail before and after an epidemic of influenza."

Neither in the United Kingdom, nor in any other country have epidemics of this disease attained very great proportions. They have been noted as occurring from time to time in Ireland—in 1846; again, in Dublin, in 1866–7, again when a number of persons, mainly soldiers, were attacked, and yet again in 1885–6, in 1890, and in Belfast in 1908. In the same year the disease prevailed in Glasgow.

In 1890 cases suspected to have been cerebro-spinal fever were observed in some of the Eastern counties of England, and especially at Oakley, in Suffolk. The Oakley cases were attended by comparatively small mortality, and in several instances multiple cases occurred in the same household. A marked prevalence of the disease preceded by two or three years the influenza epidemic of 1918. The average mortality of attacks of the disease among the troops in the United Kingdom from 1914–19 was 44·4 per cent., among the civil population the percentage mortality was 65·6. In outbreaks the numbers attacked are not as a rule so large as to produce very great effect upon the general mortality rate. Children and young adults are most commonly affected, about half the cases occurring in persons under ten years of age. An epidemic of cerebro-spinal fever is composed of a number of scattered sporadic cases which are commonly spread over several months.

In the vast majority of instances only one case of cerebro-spinal fever occurs in an invaded dwelling. In Glasgow in 1906 multiple invasion occurred in 3·8 per cent. of 186 households invaded; in 1907, 7·5 per cent in 413 households; during 1914–16, three instances of multiple cases in the same house occurred in connection with 369 cases. In a few cases previous close association with a sufferer has occurred: it is, however, exceptional for the infection of a patient to be ascribable to any known case of cerebro-spinal fever. In 1887, Weichselbaum described an organism, the " diplococcus intracellularis," or "meningococcus," which he held to be the cause of cerebro-spinal fever; it can best be cultivated on trypagar, and has feeble pathogenic properties when inoculated into animals. The same organism was isolated by Still from material derived from cases of posterior basic meningitis occurring sporadically in London; it is now held that this disease is actually epidemic cerebro-spinal fever occurring sporadically in children. In practically every case of cerebro-spinal fever the meningococcus can be recovered from the naso-pharynx of the sufferer. M. H. Gordon [1] distinguishes four types of meningococci, of which types I and III, and types II and IV, are related. Types I and II were responsible for about 80 per cent. of 518 British, etc., military cases, 1915–19. The type II group is complex and will probably be subdivided.

The disease has been defined as "a malignant fever attended by painful contraction of the muscles of the neck and retraction of the head. In some epidemics it is frequently accompanied by a profuse purpuric eruption, and occasionally by secondary effusions into certain joints (and panophthalmitis). Lesions of the brain and spinal cord are found."

The above description covers only the severer forms of the disease; milder cases are difficult to diagnose on clinical grounds, they are apt to be mistaken for influenza; if the illness lasts some time it may be diagnosed as typhoid fever, tuberculous meningitis or poliomyelitis, while if it be speedily fatal it has been regarded as typhus fever, idiopathic tetanus, or malignant measles. Bruce Low suggests that some of the epidemics of jail fever, spotted fever, petechial fever, or hospital fever, of earlier days, may have been forms of cerebro-spinal fever.

Importance has been attached to certain aids to diagnosis brought into notice in recent years. "Kernig's sign" is elicited when the thigh is flexed preliminarily on the trunk, either by causing the patient to assume the sitting posture, or by placing the thigh at right angles with the trunk as the patient lies in bed; on the attempt being then made to extend the leg, this is resisted by strong contraction of the flexors of the leg upon the thigh. Lumbar puncture not only establishes the diagnosis of meningitis but decides the nature of the infection; an exploring syringe is introduced within the theca, below the termination of the cord, and a bacteriological examination can be made of the fluid drawn off. In acute cases of cerebro-spinal meningitis, a turbid fluid is obtained in which the characteristic organisms are present in large numbers; some writers lay stress on the difficulty of detecting the organism in the later stages of more subacute cases. Sporadic cases of meningitis occur in which the cerebro-spinal fluid contains organisms resembling

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[1] "British Medical Journal," Sept. 18, 1920, p. 423.

Pfeiffer's bacillus; occasionally epidemics of meningitis have been due to the pneumococcus.

In no other disease has such importance been attached to carriers, in fact, an epidemic consists, it is said, of carriers with an occasional case. The organism can exist in the naso-pharynx without the presence of any catarrh or other unhealthy condition. Cold weather appears to favour the prevalence of the malady.

A source of danger is the breathing over and over again of air vitiated by persons suffering from the disease or by carriers; thus overcrowding of houses, especially bedrooms, etc., plays a considerable part in the spread. During the War, spread occurred in huts where the men were sleeping with their faces close together; separation of the beds to a distance of 2½ to 3 feet greatly diminished the number of carriers. Kissing is probably responsible in some measure for the spread of the disease.

In the Armed Forces during the War all immediate contacts were examined bacteriologically, and any positive contacts rigidly isolated. Although this measure did not find favour generally in civilian practice, child contacts have been excluded from school for three weeks.

The success of serum treatment depends very largely on the serum used being antagonistic to the particular type of meningococcus present; until this can be determined a polyvalent serum should be used.

Disinfection of the patient's room, bedding, etc., has been said not to be a very necessary measure in the case of a disease due to a bacillus so delicate.

Chicken-pox, Varicella—This malady has only been distinguished from small-pox for about 150 years. Attacks generally occur in children; of 6,014 cases reported from 1875–1906 in Basle, 691 were under one year, 5,080 were above one year, 21 were aged 20–40 years, 2 over 40, and one over 50.

The disease is highly infectious, ranking with measles and small-pox in this respect. Chicken-pox is usually contracted from another sufferer, but the infection can be carried short distances by a third person. Foord Caiger considers that the disease can be transmitted by air and is therefore unsuitable for cubicle isolation.

The virus is probably short-lived on clothing and other fomites; it is usually inhaled by the patient. Chicken-pox is infectious from the first sign of the rash and probably earlier, especially in those cases which present a definite prodromal stage. All patients should be regarded as infectious as long as scabs are present; the infectivity may in some instances last beyond this and be longer than three weeks, the usual period of isolation. The disease is rarely fatal. A few deaths are recorded each year; but it is possible that some of these, at any rate, represent errors of diagnosis, and that small-pox has really been in question. The incubation period varies from 11–24 days and usually lasts about fourteen days; the eruption usually appears at the outset, or is at most preceded by only a few hours of indisposition.

The chief interest of this disease is its differentiation from the mild type of small-pox found in various parts of the world and which has been erroneously held to constitute a different disease—amaas or alastrim. In this form, even with an abundant eruption, the constitutional disturbance is slight, but the elements of the eruption and its distribution are identical with those of the severe type of the disease and furnish means of differentiation from chicken-pox. Thus the pock in varicella is superficial, it is on the skin rather than in it. In variola the pock comes up from below and is always more sunk into the skin. Where the skin is thrown habitually into folds, the chicken-pox vesicle tends to be oval; its long diameter lies in the direction of the fold. In varicella the pocks occur in crops; on examination of the eruption it is generally possible to make out the fact that while some of the spots are in an early stage of development, others have already matured. Ricketts'[1] observations have clearly demonstrated the diagnostic value of the distribution of the rash in small-pox, a centripetal rash points to chicken-pox, a centrifugal rash to small-pox. Wanklyn calls attention to the assistance in diagnosis afforded by roughly counting and recording the number of spots on the hand, forearm, arm, face and front of chest; chicken-pox is indicated by the increase in the number of spots as we pass from the extremities to the trunk and a distribution as copious on the chest, area for area, as on the face. Again, in small-pox the rash is not only abundant on the face and scanty in the abdomen, but it is also more abundant on the back than on the abdomen, on the shoulders than across the loins, on the chest than on the abdomen.

In children cases with profuse eruption are the cause of some anxiety as to diagnosis; in a well-vaccinated child under ten years with an abundant eruption the disease can hardly be anything else but varicella.

In doubtful cases Paul's method is of service. The injection of fluid from a vesicle into the anterior chamber of a rabbit's eye is in the case of small-pox followed in 24–48 hours by the development of epithelial hills which in microscopical sections are found to contain Guarnierian bodies.

Cholera—This disease has doubtless long prevailed in India, and especially in the delta of the Ganges, which may be considered the enduring focus of cholera. Of its extension to Europe practically nothing is known before the early part of the last century, and it is very unlikely that earlier references to cholera, by Sydenham and others, relate to the Asiatic form of the disease.

The first great pandemic of which there is any record seems to have commenced about 1817 in Bengal, and by 1823 it had extended by way of the Caspian Sea to Astrakhan, but it did not reach Western Europe.

The second pandemic commenced in 1826 in Bengal, it extended to Russia, passed across Europe and reached America; England was attacked in 1831, the disease being imported by ships arriving in the Medway from Riga, and later being introduced at Sunderland by vessels from Hamburg; it appeared in Canada in 1832, and spread through the United States.

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[1] See "Diagnosis of Small-pox," Ricketts and Byles.

The third pandemic commenced in 1846, reached the Caspian in the following year, and prevailed extensively in Russia in 1848. London was attacked in the autumn of that year, being apparently infected from Hamburg. Edinburgh seems to have been shortly afterwards infected from Cronstadt, and other ports became implicated as a result of the arrival of ships from Hamburg. In the spring of 1849 the disease was extensively prevalent in England and in America. In 1850 it was widely diffused in America, to a less extent in Europe, and in the latter there was further diminution in its prevalence during the next two years. In 1853 cholera was widely distributed over Europe; in 1854 Great Britain was again infected from German ports. Small outbreaks, moreover, occurred in this country in 1855, 1857, and 1859, and Europe was not altogether free from cholera until 1860.

The fourth pandemic commenced in 1863, and now for the first time Europe was invaded *viâ* the Red Sea, the disease being brought to Suez by Mecca pilgrims, and spreading from Egypt to Mediterranean ports, and thence northwards. Cases occurred at Southampton, in August, 1865, and persons who were attacked at Theydon Bois were apparently infected from this source. In 1866 the disease was imported at several English seaports, and America seems to have been infected by emigrants from Liverpool. The disease lingered in Europe until 1874, though the cholera of the years following 1870 may have been due to renewed importation from the East.

It will be noted, as regards the share borne by this country in these four pandemics, that England escaped the first altogether; it was involved in 1831–33 during the second; it was attacked twice, in 1848–49 and in 1854, in the third; and again in 1865–66 in the fourth pandemic. Since the date last-named cholera has not prevailed on a large scale in this country.

During the years 1884–87 a fifth pandemic occurred and Europe suffered somewhat severely. In 1884, Toulon, Marseilles, and Paris were attacked, and 5,000 deaths occurred in France during the year. In 1885 Spain experienced an even more serious visitation; and later, Italy and Austria-Hungary were invaded. England remained, however, free from attack. In 1890 cholera again threatened an advance upon Europe; there was great mortality among Mecca pilgrims in 1891, and in 1892 the disease travelled into Russia *viâ* the Caspian. In August the Hamburg outbreak commenced, the town being presumably infected by Russian emigrants. During the same year Paris and other parts of France were implicated. The mortality in 1892 in Russia exceeded 130,000 deaths. In Hamburg upwards of 8,000 deaths occurred, and in Paris over 1,400. Cholera was imported into England from Hamburg and other European ports, but it did not spread. In 1893 the disease was still prevalent in various parts of Europe, particularly in Russia; a second outbreak occurred in Hamburg, and Altona was involved. Grimsby and Cleethorpes were now invaded, and a few scattered cases, for the most part traceable to Grimsby and Cleethorpes, occurred in various parts of this country; but the disease showed no ability to assume epidemic form, and in the succeeding years it gradually disappeared altogether from Europe, lingering longest in Russia.

A sixth pandemic began in 1902 and spread over India, China, and the Philippines; continuing, it caused great mortality among the troops engaged in the Balkan War of 1913. During the late War there was much cholera among the Austrian armies in Galicia: it also prevailed in Bulgaria, Greece and Turkey.

The fatality of cholera is very high, usually from 30 to 50 per cent. In Europe the malady has generally attained its maximum prevalence from June to August, but it has caused considerable mortality in Russia even in the depth of winter. The negro race is said to be specially liable both to attack, and to a fatal issue if the disease occurs. As regards age, children and old people contribute largely to the total number of deaths. The period of incubation varies from a few hours to three or four days. The degree of protection afforded by an attack appears to be but slight.

The comma bacillus (vibrio choleræ, cholera spirillum), discovered by Koch in Egypt in 1883, is undoubtedly the cause of the disease, but the conditions of infection, however, are complex. Cholera cultures have been swallowed without ill effect. In 1914, however, Pottevin infected small monkeys with cholera, by the administration of a purgative of 7 or 8 grains of sulphate of soda, before giving the requisite dose of cholera vibrio, thus putting them in a condition susceptible to the disease. Healthy carriers have been converted into cases of the disease by the use of purgatives. In many epidemics it has been observed that the eating of food difficult to digest has been followed by an attack of cholera.

Owing to the large number of organisms which closely resemble the cholera vibrio, only a presumptive diagnosis can be made, when large numbers of comma-shaped bacilli are found on examination of the stools. The fæces must be plated on ordinary alkaline agar, or on Dieudonné's medium, and the vibrios tested with an agglutinating serum ; true cholera vibrios are agglutinated in markedly higher dilutions than the others. Pfeiffer's reaction is used for further confirmation ; a fluid culture of the organism in question is injected into the peritoneal cavity of a guinea-pig immunised against cholera ; drops of the fluid peritoneal contents are withdrawn by means of capillary tubes and examined microscopically ; if the organisms are cholera vibrios they are immobilised, agglutinated, and dissolved. A control experiment is made with an ordinary guinea-pig. When the organisms are probably few in number, as in the case of carriers, the fæces are inoculated into an enrichment medium—Dunham's peptone solution.

The vibrios are rarely excreted in the fæces of cholera patients for more than ten days, frequently they disappear in four days.

Cholera has up to recently been considered one of the most important of water-borne diseases ; it would seem that the last three large outbreaks in London were due to the infection of the water supply.

There have been four great cholera epidemics in England, and in each of them London has suffered severely. The first epidemic was that of 1831–32. Comparatively little is known concerning this outbreak, and the statistical records relating to it are far less complete than in the case of later epidemics, inasmuch as, prior to 1837, there was no registration system in operation. From particulars collected by the Board of Health, it appears that 52,547 persons died of the disease in the United Kingdom during this, its first visitation. In "London and its vicinity" 5,275 deaths were returned between February 14th and December 18th, 1832. If this figure be accepted as representing the mortality during this outbreak, in London, the following statement showing deaths occurring in the metropolis in the four epidemics may be given :

	Deaths.	Annual Mortality per million living.
1832	5,275	3,702
1849	14,125	6,196
1854	10,738	4,289
1866	5,596	1,840

In the first three epidemics the brunt of attack was borne by certain South London populations. In the fourth epidemic East London mainly suffered.

In 1849 it was found that whereas only 15 deaths, per 10,000 persons living, occurred in six districts supplied with water taken from the Thames above Battersea, 123 deaths, per 10,000 living, occurred in the twelve districts supplied with water taken from the Thames between Battersea and Waterloo bridges. The sewage at that time was discharged directly into the river within the metropolis. In 1854 it was found that the population drinking dirty water supplied by the Southwark and Vauxhall Company suffered 3½ times as much mortality as the population drinking other water (derived from Thames Ditton). At the time of the fourth outbreak of epidemic cholera (1866), the London water companies were understood to be providing water which was "efficiently" filtered, in accordance with the requirements of the Act of 1852. It was found that (excluding the districts supplied by the East London Company), there was a marked falling off in cholera mortality in this fourth outbreak. East London, on the other hand, suffered severely; and inquiry showed that in the case of the company supplying this district there had been distinct infringement of the provisions of the Act, inasmuch as the unfiltered water of certain uncovered reservoirs had been supplied to water consumers. Since 1866 there has been no extensive epidemic prevalence of Asiatic cholera in London, and there is no evidence indicating that the disease has been communicated since that year by the water supplied by any London water company. The part played by water in disseminating cholera has, however, been studied in connection with manifestations of the disease occurring elsewhere.

Reference may be made to two outbreaks in particular—those which affected Hamburg in 1892 and Altona in 1893—inasmuch as much interest attaches to them in regard to the question as to the extent to which filtration can be relied upon as a safeguard against the danger inherent to the use of water from a polluted river. In 1892 Hamburg, supplied with unfiltered water from the Elbe, at a point where that river was relatively but little contaminated, suffered severely; while Altona, with water originally much more polluted than that of Hamburg, but subsequently purified by filtration, escaped. Later, in January and February of 1893, a number of cases of cholera developed in Altona, and the water supplied to the town fell under suspicion, inasmuch as inquiry showed that some kind of disturbance had occurred in the process of filtration. The number of germs found in the filtered water manifested increase from the 30th December, 1892, attained a maximum (1,516 per c.c.) on January 12th, then decreased again for a short time, but rose again in the last week of January. Examinations made in February showed that a particular filter was then mainly at fault, and some experiments which were instituted led to the conclusion that the defect in the process of filtration was due to freezing of the surface layers of sand during the process of cleansing the filter.

A comparatively small outbreak of cholera occurred in Hamburg in September, 1893, and in that year, as indeed had also been the case in 1892, a prevalence of enteric fever was manifested, which reached its height about three weeks later than that of cholera. There was thus reason for supposing (having regard to the length of the incubation period in the two diseases) that the infection of both was communicated at about the same time. At the precise date when the mischief must have been done, bacteriological examination of the water supplied in Hamburg was yielding such unsatisfactory results as to lead to the conclusion that local pollution of the main conveying filtered water must exist. Inquiry showed that a settlement, which had taken place in some masonry, permitted raw Elbe water to obtain access to the filtered water conduit. Steps were promptly taken to remedy this defect, and a marked reduction in the number of organisms in the water was immediately manifested. The source of pollution having been cut off, the outbreak soon came to an end.

Another water outbreak which is deserving of mention is that which occurred at Stettin. The town was supplied with filtered water obtained from the river Oder. Filtration was, however, performed with undue rapidity, inasmuch as the filtering area was inadequate to meet the demands made upon it. Bacteriological examination had from time to time given unsatisfactory results, but, shortly after the commencement of the outbreak, the presence of the cholera vibrio was actually demonstrated in water from the reservoirs of the filters supplying the town.

In India to-day the enforcement of measures to prevent spread of cholera by means of drinking water constitutes one of the principal duties of health officers.

Infection through the air is not probable. The cholera vibrio is a frail organism and dies rapidly when dried or exposed to light and other injurious influences. Fomites such as bedclothes, clothing and other articles, including spoons, dishes, toys, etc., contaminated with discharges from patients, are possible sources of infection ; Koch found that the comma bacillus can multiply rapidly on the surface of moist linen. As, however, the organism is so readily destroyed y desiccation and easily crowded out by saprophytic micro-organisms, o be effective the contamination must be recent. In crowded quarters, here many people are living under uncleanly conditions, the disease s probably contracted from infected fomites ; doctors, nurses and thers in close contact with patients, have not been infected when he ordinary simple precautions required are taken.

Milk is probably not a frequent medium of infection, its acid eaction inhibits the growth of the cholera vibrio. In the case nvestigated by Simpson of an outbreak of cholera on board the ship *rdenclutha*, lying off the port of Calcutta, the implicated milk was ound to be diluted with water derived from a tank to which the holera virus had obtained access.

Food, such as green vegetables and fruit, washed with infected ater, can convey the disease ; the organism can live on fresh bread, utter and meat for a week.

Cholera vibrios can live in the intestines of *flies* for at least three ays ; these and other insects may spread the disease mechanically s well.

During a cholera epidemic in 1912 at Puri, in which water could be excluded s the vehicle of infection, flies were so abundant as to amount almost to a plague ; heir arrival and disappearance synchronised with the arrival and departure f the great mass of the pilgrims, showing that temporary breeding-places must ave existed in Puri.

Flies caught in the neighbourhood of collections of cholera cases showed the cholera vibrio on the external appendages and also in the contents of the limentary tract.

Apart from specific pollution of water and milk, and the contamination of food by flies, or infected water, there remains the still more difficult problem of detecting and dealing with healthy cholera carriers before they can cause mischief to others. Such carriers may be responsible for outbreaks on ships. In 97 per cent. the carrier period is over in a month, but in the remainder the conditions may last as long as two months.

In the outbreaks occurring in 1893, in this country, the relation of polluted shell-fish and fish to spread of cholera was suspected.

As regards prevention the dangers which have to be especially guarded against are stated, in a Memorandum issued in 1892 by the Local Government Board, to be the danger of water supplies " where there is outflow, leakage, or filtration from sewers, house-drains, privies, cesspools, foul ditches or the like, into springs, streams, wells, or reservoirs from which the supply of water is drawn, or into the soil in which the wells are situate." To these should now be added the danger from sewage-contaminated fish or shell-fish.[1]

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[1] See Thorne Thorne : Introductions to Reports and papers on cholera in England in 1893, L.G.B., 1894, p. xxviii.

The importance of disinfection of excremental matter, urine, and vomit and the careful washing of their hands by attendants on the sick, need not here be insisted upon. Carriers should be searched for among the contacts.

In India the extent of the disease has been lessened by taking adequate sanitary precautions in connection with the vast numbers of Hindus who assemble at the great religious fairs and pilgrimages. Temporary supplies of pure water, adequate latrine provision, sufficient shelters and lodging-places for the pilgrims, are being provided, and arrangements are also made for the sale of food at the fairs.

Cholera vaccines have been used with considerable success for prophylaxis, especially in India; they are a powerful but transitory preventive. In Egypt all pilgrims to Mecca are vaccinated against cholera before leaving Suez; on their return they are traced, and the stools of those showing any intestinal symptoms are bacteriologically examined.

The mortality from the disease has been appreciably lowered by the use of Rogers' method of treatment, in which large quantities of salt solution are repeatedly injected into the veins.

Dengue—This disease is known to have prevailed from time to time for more than a century in various parts of the tropics, and at long intervals it has assumed the characters of a pandemic, spreading widely along lines of human intercourse, attacking entire communities within a brief space of time, and then disappearing again as suddenly as it came. It rarely extends into temperate regions, though it has during hot seasons prevailed as far north as Philadelphia, and it has been seen in southern Europe. The last worldwide prevalence of dengue was in the years 1870–3.

Headache, pain referred to the back of the eyeballs, backache, and pains in the limbs, accompany the fever; the illness is particularly likely to be confused with "influenza," and the mistake appears to have often been made. Furthermore, some, at any rate, of the widespread prevalences described as dengue seem to have really formed part of influenza prevalences. The illness is characterised by the sudden onset of an initial bout of fever, lasting three or four days, a remission, and a terminal rise of temperature for two or three days—the saddle-back temperature course. The initial rise of temperature is accompanied by an erythematous eruption; the terminal fever is as a rule accompanied by a "terminal" rash, consisting of slightly raised circular patches, which may later run into one another, and present an appearance not unlike that of measles; or again, the entire area of the skin may be covered with one unbroken sheet of red, this being not infrequently the case at favourite sites of the eruption, such as the hands, wrists, elbows, and knees. During convalescence severe pain may be experienced in the neighbourhood of one or more joints, the limb may be held quite stiffly for some days or weeks owing to affection of the muscular attachments; wastng of muscles may supervene. Apparently the stiffness of gait and difficulty of movement occasioned by the disease led to its receiving the name of dandy fever (the term dengue, moreover, signifies a dandy).

The incubation period is probably from one to four or five days; elapses sometimes occur; the disease is rarely fatal, though it may eave behind it a persistent condition of impaired health.

The micro-organism which presumably causes dengue is an ultramicroscopic filterable virus which is conveyed by mosquitoes, Aëdes argenteus, Stegomyia fasciata, the tiger mosquito and possibly Culex atigans.

Dengue-like Fevers—A disease termed Pappataci fever occurs in the summer eason in Dalmatia, Herzegovina, and the Adriatic littoral; it is characterised by fever lasting about three days, followed by prostration; death very rarely occurs. The organism concerned is an ultramicroscopic virus; the serum of a patient after it has been passed through a Berkefeld filter can, when inocuated, give rise to the disease. Doerr reproduced the disease by feeding species of phlebotomus pappatasii (erroneously known as a sand-fly) on a sick person, ransporting them to a locality far from the disease, and allowing them to bite healthy persons.

Phlebotomus Fever (Sand-fly fever), an apparently identical disease which occurs in Malta, was reproduced by Birt in the same way. He found that the flies were not infectious till seven days after biting the sick; the causal organism, t would seem, passes through a developmental cycle in the fly.

The disease also occurs in Northern Africa, including Egypt, Arabia, Corsica, Italy, and Portugal, where it is also known as sand-fly, or three-day fever.

Summer Diarrhœa. Epidemic Enteritis. Zymotic Enteritis. Epidemic Diarrhœa—The opinion has now for some years been gaining ground that under the heading "diarrhœa," the mortality returns have included many deaths due to a specific malady (or specific maladies) which particularly needs to be further studied with a view to obtaining knowledge upon which to base preventive measures. The deaths mainly occur in children under two years of age, and in the summer season. Comparatively few in number in the earliest years of registration, they soon afterwards increased, and then showed no sign of declining, until the end of the century, the average annual mortality ranging between some 10 to 30 or more, per 1,000 births. A fall in the rate occurred after 1900, particularly marked after 1911.

The term diarrhœa has, no doubt, been applied to many deaths from the specific malady, but other designations have also been employed for this disease, such as gastro-enteritis, muco-enteritis, etc. With a view to securing some sort of uniformity the College of Physicians in 1900 recommended the use of the term "epidemic diarrhœa," or of one or other of two synonyms, "epidemic enteritis" or "zymotic enteritis."

The disease is conspicuously influenced by season. Fig. 76 shows the average number of deaths recorded in each week in London, during the years 1841–90. Of late years the seasonal maximum has, however, been a few weeks later than that shown in the figure. Again, diarrhœa specially prevails among young children. Ballard noted attacks occur chiefly in children under 5 years of age. After 5 years the incidence greatly lessens; beyond 25 it gradually increases again. "Among children under 5 years of age, the incidence is comparatively small upon those under 3 months, after which age it apparently increases, beginning to diminish somewhat between the ages 1 to 2 years." Most of the deaths occur during the first year, the 3 to 6 months' age-group having the highest mortality.

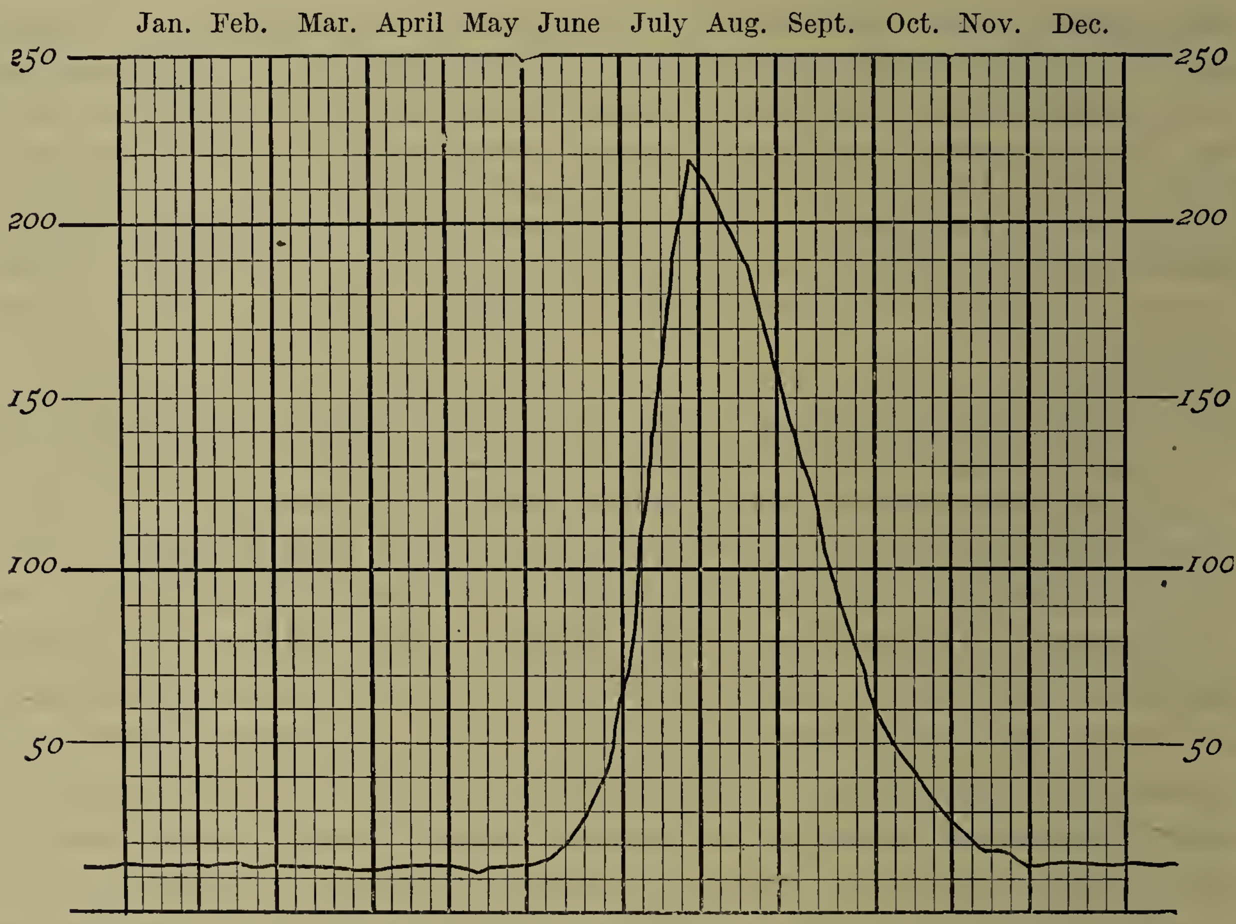

FIG. 76.—Average number of deaths from diarrhœa, registered in London in each week, 1841–1890.

The seasonal prevalence of the malady led to its being generally attributed, years ago, to the eating of fruit, but as a matter of fact the seasonal abundance of the common fruits does not correspond closely with the seasonal prevalence of diarrhœa, and the mortality mainly occurs at ages at which but little fruit is eaten. Other obvious lines of inquiry were the association of the disease with high atmospheric temperature, and with prevalence of flies.

That in years of considerable epidemics the occurrence of the disease is not *directly* related to high air temperature is shown in several ways. The death curve bears no resemblance to the mean weekly maximum air temperature curve and lags several weeks behind it. Niven pointed out that neither the highest death-rate, nor the greatest increase of cases coincides with, or closely follows, the maximum atmospheric temperature. Ballard and others after him have held that it is not atmospheric temperature that is of importance, but soil temperature, yet a high temperature has been registered by the 4-foot earth thermometer in June, without a marked rise in diarrhœal mortality; nor does this increase of the earth's temperature to 56° F. (or 58° F.), thus measured (see p. 159) invariably coincide with a marked increase in diarrhœal deaths.

The high atmospheric temperature possibly acts *indirectly* by favouring the breeding of flies. In years with poor early fly-breeding conditions, but good breeding conditions in the third quarter, the diarrhœa death curve only rises when sufficient time has elapsed for flies to emerge, and by this time the temperature curve has often fallen (*e.g.*, 1905). No doubt when a high air temperature coincides with a period when flies are numerous and active it has a profound influence on the incidence of the disease.

O. Peters observed in Mansfield, that houses containing infants up to two years of age were more often attacked than others, and that in the houses with very young children, much opportunity for fæcal pollution of the houses (and food) and ready access of flies to motions was possible. Doubtless unlimited opportunities are afforded to flies of conveying presumably infected materials from the intestinal discharges of patients to the food of healthy infants, especially to milk and sugar. A close relationship exists between the curves graphically illustrating the rise and fall of the annual outbreak of epidemic diarrhœa and the rise and fall of the annual prevalence of flies. Also, in the hot summer of 1911, flies were numerous and epidemic diarrhœa very prevalent, but in the cold and wet summer of 1912 flies were few and epidemic diarrhœa uncommon. Evidence of this nature whilst very suggestive is not altogether conclusive.

In some outbreaks Morgan's No. 1 bacillus is very frequently present in the fæces of sufferers, and it is perhaps significant that while it has been found not uncommonly in the intestines of flies associated with such outbreaks, it seldom occurs in the intestines of flies from non-diarrhœa-infected localities. The relation between the raised atmospheric temperature and the increased incidence of diarrhœa in infants has of late years also been ascribed to lack of adjustment of the baby's diet to his altered food requirements.

For most of the year in this country, food must be provided to maintain the body heat; roughly one-third of the food of an infant serves this purpose; in summer as well as in the colder months of the year, the bottle-fed baby is usually given at least the same quantity of food, and often more, because he demands more fluid to relieve his thirst.

The breast-fed baby, feeling less hungry, sucks less vigorously, and so obtains less food from the mother's breast. Her milk becomes more watery in hot weather. Breast-fed babies rarely suffer or die from diarrhœa, but in bottle-fed babies, under these circumstances dyspepsia sets in, the child is less resistant to infection, and if given cow's milk containing pathogenic bacteria, he acquires on top of his original dyspepsia the infective form of the disease.

Excessive heat not only encourages the growth of bacteria in milk contaminated by flies, dust, or unclean hands, but also lowers the resistance of the child to infection. The power of an infant to maintain a constant body temperature is ill-developed, he has often, in addition to attempting to throw off an excessive amount of heat derived from his food, to contend with the effects of living in stiflingly hot rooms, small and ill-ventilated, with no cooling draughts blowing through them.

H. Charles Cameron holds that some of the children exposed to great heat who suffer from diarrhœa are suffering primarily from a disturbance of the heat-regulating centre; a few are cases of heat stroke with cerebro-spinal symptoms, in which diarrhœa and vomiting are only incidental.

Many observers have pointed out the existence of a relation between a deficiency of rainfall in the third quarter of the year and an excessive diarrhœal mortality rate; it is generally held that a low diarrhœal death-rate depends more on the number of rainy days than on the rainfall. Ballard considered that the influence exerted by rainfall was not direct (not a "washing of the atmosphere," so to speak), but indirect, operating by preventing the rise and hastening the fall of the temperature of the earth.[1] As regards air movement —in the diarrhœal season, calm promotes, and high winds tend to lessen, diarrhœa; the continual movement of the air may account for the lessened diarrhœal death-rate in South Coast towns pointed out by Newsholme.

Abundant evidence exists as to the higher diarrhœal mortality rate among the poorer members of the community; neglect of the early symptoms and an inferior degree of cleanliness may be responsible; the disease is found especially in overcrowded houses. Niven remarks on the manner in which mortality from lung disease and diarrhœa alternated in the same family, and the frequent association of this mortality with septic sores; uncleanly habits of the mothers would seem to be responsible.

Dirty houses favour diarrhœa, but in view of the association of human intestinal organisms with the disease, it would seem probable that lack of cleanliness in the handling of food in the home was the factor directly concerned.

Dirty houses also favour the breeding of *house* flies.

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[1] See Supplement to the Report of C.M.O. of the L.G.B., 1887.

Inquiries as to milk supply have failed to show the particular incidence of the disease on any one milk-round ; although the mortality from diarrhœa is much greater among the poor than those in better circumstances, practically the same class of milk goes to both sets of houses. These considerations, together with the occurrence of diarrhœa in breast-fed babies and infants fed on condensed milk, point to the probability of the infection of the food taking place at the home.

In the United States of America, Flexner and his co-workers have found the dysentery bacillus, especially of the " Flexner-Harris " and " Shiga " types, in the intestinal discharges of children and infants suffering from infantile diarrhœa in from 60 per cent. to 70 per cent. of the cases. In this country however, although in isolated instances the dysentery bacillus has been found, the organism most commonly associated with the disease is Morgan's No. 1 bacillus. But the primary causes of summer diarrhœa cannot be regarded as an infection by any one organism, B. paratyphosus B, Gärtner's bacillus, Bacillus F (Orr and Alexander) and even Bacillus Coli Communis having been held responsible for some of the cases.[1] In Australia infantile diarrhœa has been found to be associated with the presence of B. fæcalis alkaligenes.

The general conception of epidemic diarrhœa as a single disease affecting infants in the summer months only, has been shown to be incorrect. It is evident that summer diarrhœa includes several diseases ; this is shown not only by bacteriological investigation, but also by a study of the clinical aspects of cases of summer diarrhœa as occurring in the homes, and not only of the severe type of case seen in the wards of hospitals.

The malady is not confined to the earliest years of life ; although very much more widespread in the third quarter, the disease occurs at all seasons of the year. Several observers have demonstrated the existence of multiple attacks in houses, affecting not only children but adults, the date of the onset of the disease in the sufferers usually being consecutive.

Attempts to prevent contamination of milk by flies have apparently been productive of distinct benefit so far as the mortality among infants is concerned.

Prevention—An important precaution is to scald the milk at once on delivery. Milk should be bought twice a day. It should be placed in clean receptacles fitted with air-tight lids.

Every care must be taken to keep dust out of food ; milk must be covered and sugar covered or kept wrapped up. Clean feeding-bottles should be used ; no comforter should be allowed.

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[1] Cases of infantile diarrhœa have been shown in Manchester especially to be in reality cases of typhoid fever.

After attending to the baby or other child the mother should at once wash her hands carefully and scrub the finger-nails, which should be kept short. Before preparing the baby's food the hands should always be washed. It is not wise to let anyone put their fingers into the baby's mouth to feel for teeth or rub the gums unless they have just washed their hands carefully.

Children should not be allowed to crawl on the floor or on the ground, lest their hands or clothes should become soiled and the infective material conveyed to their mouths. They should not be allowed to suck their clothing, which should be kept very clean.

Steps must be taken to prevent flies getting to the motions. Soiled napkins should at once be put into enough water to cover them. Water-closet pans should be kept empty and clean; any human excrement in the neighbourhood of houses cleaned up and suitably disposed of by burning or otherwise. Every possible step should be taken to prevent flies breeding; as much of the household refuse as possible should be burnt, the remainder being placed in the ashpit or ashbin, which must be kept in a dry condition and covered.

The utmost care should be taken to ensure the frequent removal from the neighbourhood of houses of organic matter such as the contents of midden-steads; such matter encourages the propagation of flies. The surface of such manure heaps should be plentifully sprinkled with quicklime every time an addition is made.

One of the most important preventive measures is to induce mothers to continue breast feeding; the mortality among breast-fed babies from summer diarrhœa is decidedly less than among artificially fed babies. Investigations in Birmingham showed that, of the babies dying from diarrhœa in the third quarter of the years (1904–10), roughly nine out of every ten were artificially fed.

In the hot months of July, August and September, babies should not be weaned.

Diphtheria—In the middle of the second century of the Christian era, Aretæus described a throat affection, angina, which there can be no doubt was what is now termed diphtheria.

The Arabian physicians described "angina," but it is not until the sixteenth century that clear accounts of what is now known as diphtheria are forthcoming In 1765 Home's work on croup appeared. The new denomination, undoubtedly, tended to obscure, as Bretonneau says, the relationship of "a disease observed from the most remote antiquity."

In 1821 Bretonneau published his first memoir describing "diphthérite," or, as he afterwards termed it, "diphthérie" (from the Greek word *διφθέϱα*, a skin). He wrote four further memoirs on the subject, referring, *inter alia*, to a school epidemic which occurred at Tours, and to outbreaks in the barracks of that city. It was some years, however, before the nomenclature introduced by Bretonneau was popularised in this country. The great epidemic of the late "fifties" and the early "sixties" brought diphtheria into special prominence. Netten Radcliffe states that from 1854 onwards croup, thrush, quinsy, and noma showed increased prevalence; in fact, he adds, "it is not too much to say that all the affections allied to diphtheria prevailed epidemically contemporaneously with diphtheria."

Confusion of nomenclature has continued up to recent times; the extent to which deaths previously ascribed to other forms of throat malady have been ascribed to diphtheria was first studied comprehensively by Sykes ("Public Health," vol. vi.). Scarlet fever and diphtheria were not distinguished by the Registrar-General till 1855, and even when fatal cases of those diseases were separately recorded, after that year, there can be no doubt that large numbers of what were really diphtheria deaths were returned under the heading croup. A table given in the Sixtieth Annual Report of the Registrar-General (page xxiii) shows striking diminution in the number of deaths ascribed to croup, from 286 per million living in 1859, to only 35 per million living in 1897.[1] It must not be assumed, however, that all the deaths recorded as croup, during those years, were really diphtheria deaths, for, as Whitelegge has pointed out, the seasonal mortality curve of croup approximates more closely to the laryngitis curve than to that of diphtheria. Moreover, "croup is more fatal to males than females upon the whole, the mortality among females being lower up to fifteen years of age. The highest mortality in both sexes occurs in the second year of life. In all these respects 'croup' is allied to laryngitis rather than diphtheria." The extent to which transference between scarlet fever and diphtheria may have occurred since 1859 has been examined by Shirley Murphy, in connection with the altered age-incidence, observed since 1871, in the last-named disease.

The localisation of the disease in situations other than the fauces and trachea must be borne in mind. Fibrinous rhinitis caused by diphtheria bacilli occurs both in children who appear ill, and in those without any severe constitutional symptoms. The vulva may be primarily involved, also the conjunctiva, and wounds. When a slight abrasion occurs the skin may be affected; diphtheria bacilli can often be recovered from sores present near the nostrils of a child, as well as from the nasal discharge.

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[1] The Registrar-General points out in the supplement to the Fifty-fifth Annual Report, p. xxvi, that it is his practice "to class under the head of diphtheria all deaths which are referred to 'membranous croup,' deaths returned, as from croup simply, being referred to the heading 'croup' among diseases of the respiratory system."

The death-rate from diphtheria recorded in England and Wales in 1859 was 517 per million living; this rate has never since been attained; the mortality declined steadily during the "sixties"; but in the "seventies," "eighties," and "nineties" there was a fairly steady increase in the recorded rates, with some tendency to manifestations of increased prevalence, extending over a few years. In 1893, a year of high prevalence, a mortality of 318 per million living was recorded.

Since the close of the War increased mortality from diphtheria has again excited concern both in this country and in the United States. The use of the Schick test and subsequent immunisation by toxin-antitoxin inoculations in susceptible persons has been introduced in the U.S.A. with a view to obtaining greater control over the disease.

Influence of Climate and Season—The disease is less common in the tropics than in temperate and cold climates. The seasonal curve,

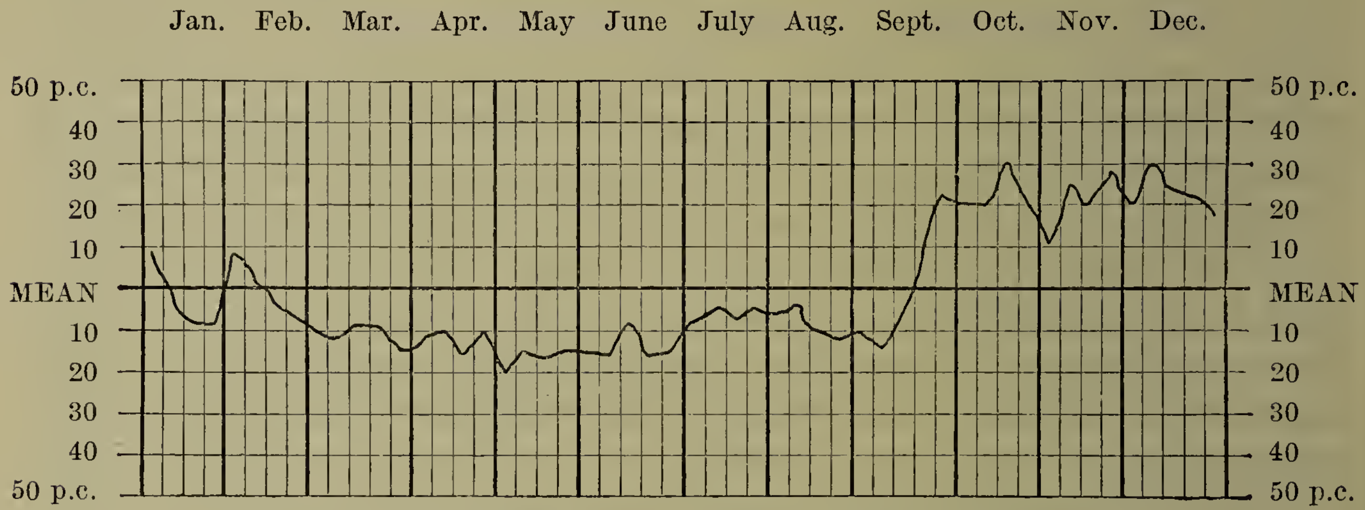

FIG. 77.—Diphtheria in London (forty years 1861–1900).
The mean line represents an average weekly number of 20 deaths.
(*After Shirley Murphy.*)

Fig. 77, shows that the malady tends especially to prevail in the last quarter of the year in London, and the relation to cold and damp weather has been noted, though not invariably, elsewhere. Perhaps dryness and allied atmospheric conditions operate rather by promoting individual susceptibility, than by directly increasing the virulence of the diphtheria germ. Diphtheria presents seasonal variations of age-incidence and fatality, and similar phenomena are observed in the case of scarlet fever.[1]

Longstaff urged, from consideration of the recorded mortality of the "sixties," "seventies," and "eighties," that diphtheria was especially a disease of sparsely populated localities. He prepared the following table:—

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[1] The matter was fully discussed by Shirley Murphy, in the "Transactions of the Epidemiological Society" for 1897–8.

Districts according to density of population.	1855–60.	1861–70.	1871–80.
Dense districts, or those with less than 1 acre per person	123	163	114
Medium districts, or those with from 1 to 2 acres per person	182	164	125
Sparse districts, or those with over 2 acres per person	248	223	132

This behaviour of diphtheria led Longstaff to conclude that "the cause or causes of diphtheria should not be sought for primarily in any high development of civilisation, such as sewers; but rather in some condition associated with a more primitive mode of life." In the final decade of the last century, however, diphtheria conspicuously invaded the towns, and notably the metropolis. It has been thought to explain this altered behaviour, as resulting from increased facilities of communication, or from the aggregation of susceptible children, and there can be no question that this last-named factor accounts, at any rate in some part, for the phenomenon. Moreover Netten Radcliffe pointed out that diphtheria was prevalent in London in the fifties and it presumably spread from the towns to the country.

Influence of Age and Sex—Diphtheria is especially a disease of the first ten years of life, and particularly of the first five; infants up to about six months have an inherited immunity. There is notable excess of female mortality from about the third year of life to the thirty-fifth, and this has been explained by the greater exposure of women to infection, incidental to their attendance upon the sick; but, as Downes has observed, it is remarkable that the excess should be already apparent at such very early ages. The feminine habit of frequent kissing may be responsible. The mortality, taking the two sexes together, attains a maximum at the age-period 3–4. It is markedly less under one year, however, than at the other ages in the 0–5 age-group. After ten years of age the mortality falls notably, and it becomes comparatively insignificant after the fifteenth year. The altered age-incidence which was manifested during the last three decades of the nineteenth century has been ascribed as being due in the main to school influence.

Cause and Dissemination—The bacillus, first described by Klebs, and afterwards studied by Löffler, and known as the Klebs-Löffler bacillus, has been generally regarded as the cause of diphtheria, and its presence in the throat is appealed to as the final test of the existence of the malady in particular individuals.

The variety of forms assumed by the diphtheria bacillus not infrequently gives rise to much difficulty in their detection by morphological examination alone; a knowledge of the types worked out by Westbrook, and later by Graham Smith, is of great assistance.[1]

The matter is complicated by the existence of avirulent diphtheria bacilli; the lack of virulence is demonstrated by the injection of animals, either subcutaneously or intracutaneously.[2]

In large towns, in which diphtheria is constantly present, and among communities of children, in school outbreaks, the bacillus has been found in the nose and throat in quite an appreciable percentage of apparently healthy persons who are not known to have suffered from diphtheria; these are termed healthy "carriers." Again the organism may persist in patients for some months, or even years, after the appearance of the fauces becomes normal. Chronic intermittent carriers also occur.[3]

Studies from among different places show that "not more than 2–3 per cent. of the normal population, excluding persons who have recently come into contact with diphtheria cases, harbour the diphtheria bacillus, while if virulent bacilli alone are considered, not more than 0·2 per cent."[4]

Diphtheria is spread at different times by direct contact, *e.g.*, when a mother kisses her child; the possibilities of spread by indirect contact [carriers among children] are, however, so numerous as to render these modes of infection more common. In and out of school the common use of pencils, pocket-handkerchiefs, etc., must be a frequent mode of dissemination.

At one time diphtheria was commonly supposed to be spread by sewer and drain emanations; but it is now generally accepted that effluvia, of the kind referred to, operate merely by bringing about a catarrhal condition of the mucous membrane of the throat, and thus predisposing persons subjected to them to an attack of the disease. Dust may play a part in the spread. In an outbreak of diphtheria in 1914 in the Winsford Urban District, where house refuse was dumped on to the roadways to await collection by the scavengers, and owing to scarcity of water the streets were inadequately watered in dry weather, Copeman suggested that the inhalation of the dust, which was blown about in large quantities, may have caused sore throats and favoured subsequent diphtherial infection, or may even have been an occasional medium for its conveyance.

Milk giving rise to diphtheria is usually contaminated by cases of the disease or by carriers handling the milk on the farm, or at the dairy or milk shop. The form of the disease responsible for the infection of the milk is more frequently faucial, but skin lesions or cellulitis may also be responsible.

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[1] See also p. 68, Diphtheria, Medical Research Council's Report, 1923.

[2] See p. 30, Report of Ministry of Health on diphtheria, No. 10, 1921.

[3] See annual reports of the London County Medical Officer for 1912, p. 146; for 1913, p. 198; for 1914, p. 129; and for 1915, p. 33.

[4] Savage, "Public Health," April, 1917, p. 153.

An instructive outbreak due to infection of milk occurred in South London in 1914. Milk supplied from a certain Lambeth dairy was the factor common to all houses affected in the six districts concerned. The epidemic was brought to an end by the pasteurisation (on the recommendation of Priestley) of all the milk sent out from the dairy. The milk was supplied from seventeen farms in Surrey and Sussex; a letter was sent to the M.O.H. of the districts concerned, asking for an examination of each farm, and of the milkers. On a Sussex farm a milker was found suffering with "milker's finger" so severely as to require amputation; on bacteriological examination, virulent diphtheria bacilli were found in the lesion. At this farm, on the hands of two other milkers, were found sores: from one virulent diphtheria bacilli were isolated. Five of the cows at the farm had irregularly-shaped sores situated on the upper half of the teats; as they were healed no bacteriological examination could be made. In view of the attendant circumstances, it seemed that the sores on the cow's teats became infected with diphtheria from some unknown source; and that the infectivity of the milk was increased owing to the accidental infection of the milker's hands from the diseased teats.[1]

A possibility of the existence of a specific cow malady due to diphtheria was demonstrated during a milk epidemic described by Ashby; ulcers were found on the teats of cows belonging to two separate farms. From one of the ulcers diphtheria bacilli were recovered, the possibility of the cows in *one* of the farms being infected from a human source could not be excluded.[2]

Power, in a milk-borne epidemic at York Town and Camberley, in 1886, had found that two cows presented chaps on their teats, and subsequently one cow which had suffered in this way developed a "scab or crust, not unlike those which at a later stage of their malady, had been observed to replace ulcers on the udders of certain Hendon cows." At Barking in 1888, and at Croydon in 1890 and 1891, contagious eruptive disease of the teats and udders of cows was also found associated with spread of diphtheria to persons consuming the milk of these animals. Klein found in 1890 and 1891 that inoculation of the diphtheria bacillus under the skin of the shoulder of newly-calved cows was followed, in one instance by the appearance of a papular eruption on the udder and one teat; vesicles and later crusts were developed and visceral changes, corresponding to those produced by inoculation of the diphtheria bacillus in the cat, were also observed: finally, the presence of the diphtheria bacillus was demonstrated in the milk of the affected cow.

But in 1902 Dean and Todd are held to have shown that these lesions are not due to diphtheria or vaccinia but to a separate infective disease. And the organisms which Klein demonstrated in the milk may have been non-virulent diphtheroids the occurrence of which in milk was not generally known at that time.[1]

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[1] See report of H. A. Macewen to L.G.B. New series, No. 94, 1914. Also annual report, L.G.B., 1913-14, pp. xlii and 97.

[2] See "Public Health," December, 1906, p. 154.

Other animals may be affected by the disease; thus, it has been described as occurring in the cat. Simmons records a fatal attack occurring in an elderly lady after fondling a cat. Throat cultures from the throats of the lady and the cat showed morphologically identical bacilli, which were virulent for guinea-pigs. The illness in the cat was passed on to another cat, who died within eight days; post-mortem virulent diphtheria bacilli were grown from membranous particles on the vocal cords.[2]

An outbreak due to infected ice-cream has been described in U.S.A.

The curious way in which cases of diphtheria and scarlet fever occur in association with one another is noteworthy. In instances in which infective throat malady affects several members of a family, some of the cases may present examples of what appears to be the one form of disease, and some of the other. Again, in milk outbreaks, a like source of confusion has been noted. The precise nature and origin of the cases of so-called "post-scarlatinal diphtheria" has been the subject of numerous inquiries of late years. Many of these cases are considered to represent instances of the engrafting of a second disease during recovery from the first. Certainly many of the cases of scarlet fever admitted to hospital are found to be carrying diphtheria bacilli on admission.

The minimum limit of the period of incubation of diphtheria can easily be fixed—the disease may develop within twenty-four hours of exudation material being coughed directly into the mouth of a doctor or nurse: the usual period is two or three days. As we know that the bacillus can exist for a long time in the mouth of a healthy person before infecting him, the maximum period cannot be definitely stated; for administration purposes the period of a week is fixed. The length of time during which cases may continue to be infective is not precisely known. Bacilli may still be present in the throat after weeks or even months. Second attacks of diphtheria in the same person are not infrequent.

The case-mortality of diphtheria has undergone marked reduction since the introduction of the use of antitoxin. The question of the antitoxic serum treatment was very fully considered in the Medical supplement to the Report for the year 1896 of the Statistical Committee of the Metropolitan Asylums Board. It must suffice here to state that the mortality observed in all cases treated in hospital in

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[1] See p. 345, "Medical Research Council's Report."

[2] See "Medical Science," April, 1921. But the writers in the Medical Research Council's Report on Diphtheria (see p. 348), points out that the bacilli from the old lady did not ferment saccharose while that from both the cats did. They do not accept the view that a cat can suffer from diphtheria.

1894 (a pre-antitoxin year), as compared with 1896 (an antitoxin year), was 29·6 per cent. as against 20·8. The mortality under five fell from 47·4 to 30·2 per cent. It was found, in dealing with the cases treated with antitoxin, that a marked difference was noticeable in the percentage mortality, according to the day of the disease on which the cases first came under treatment.

PERCENTAGE MORTALITY IN RELATION TO DAY OF DISEASE ON WHICH CASES CAME UNDER TREATMENT.

Day of Disease.	1894.	1896.	Difference.
First	22·5	4·7	17·8
Second	27·0	12·8	14·2
Third	29·4	17·7	11·7
Fourth	31·6	22·5	9·1
Fifth and over	30·8	24·6	6·2
All cases	29·6	20·8	8·8

It is thus seen "that the percentage mortality of cases admitted on the same day of the disease is less in every instance in the year 1896." Moreover, the difference is most marked in the patients admitted on the first, second, and third days of illness. Furthermore, the beneficial effect of antitoxic serum treatment was found to be specially pronounced in laryngeal and tracheotomy cases.[1]

To secure the early administration of antitoxin the disease should be diagnosed as often as possible on clinical appearances.

C. B. Ker suggests that 2,000 or 3,000 units should be injected as a routine practice by any doctor who thinks it necessary to take a swab; the routine use of 8,000 units would however be better in order to combat possible severe infection. The risk of anaphylaxis following on any subsequent injection of serum can safely be disregarded. It is said that post-diphtheritic paralysis has been of more frequent occurrence since the introduction of serum treatment; but even if this were a fact, it must be borne in mind that a larger number of patients reach the stage at which paralysis is apt to develop, nowadays, than was formerly the case. Albuminuria, too, is said to have become more common, but this appears doubtful. Certain minor effects—urticaria, joint pains, and swellings, etc., have been noted as being produced; they appear to be attributable not to the antitoxin itself, but to the vehicle, the serum, in which it is administered. The subject of "return cases" will be referred to in connection with scarlet fever.

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[1] In the Annual Report of the M.A.B. for 1910 the case is stated as follows:—

Before the use of antitoxin, the average mortality, taking all cases of diphtheria together, was 30·4 per cent. It came down to 8·3 per cent.

The average mortality of the cases of laryngeal diphtheria came down from 62 per cent. to 11·7 per cent.

The average mortality of the tracheotomy cases came down from 70 per cent. to 20 per cent.

In diphtheria, proper isolation of the patient and careful disinfection of any articles used by him are specially valuable as means of preventing spread of infection; care is particularly necessary in dealing with discharges and expectorated material, and disinfection of clothing and bed linen should be thoroughly carried out.

Ker's routine in Edinburgh is to detain all convalescent "carriers" in hospital for at least 12 weeks, when the virulence of the organism is tested. If avirulent the patient is discharged; no return cases have been traced to any such patients. If virulent, he holds that the patient should be detained and tonsillectomy considered. Ker has not had to keep patients in hospital for more than 4 to 5 months. This operation does undoubtedly, at times, abolish the "carrier" condition.

In practice the inoculation of carriers with autogenous vaccines, as carried out at St. Mary's Hospital, London, appears to shorten the period of "carrying."

The spread of fatal diphtheria in families has followed on the premature release of a brother or sister from isolation, after the examination of a single swab, even when no clinical signs were present.

Children from infected households, even though they present no signs of illness themselves, should be kept away from other children, until swabs of their noses and throats are free from virulent diphtheria. In localities where diphtheria is prevalent, much benefit may result from the examination of the noses and throats of school children, with a view to isolation of any suspected case at an early stage. Swabs should be taken of the nose and throat of any child with redness or soreness of the throat, sores in the nostril or upper lip, or with the nose blocked with coagulated blood. Any children coming from homes where there are alleged to be cases of sore throat or who have recently been absent on account of sore throat, even if slight, or swollen glands, should be swabbed. When any class is swabbed, the teacher also should be included.

Although the immunity induced only lasts for about three weeks, and takes about 24 hours to develop, the injection of antitoxin (500 units for a child, 1,000 for an adult) does bring about the cessation of an outbreak. Such was our experience of an outbreak at a Poor Law School for children near Brighton, in which a large number of the children had been attacked. The procedure is not ideal because it is found that as the protection conferred by the antitoxin wears off, if carriers are present in the institution or if new entrants are admitted, cases of diphtheria again begin to occur amongst those who have been given the antitoxin. One cannot well go on indefinitely repeating the injections of antitoxin every fortnight, and in any case the duration of the protection conferred becomes shorter with succeeding injections.

A much better procedure consists in at once swabbing every inmate and also applying the Schick test. This consists in the injection of $\frac{1}{50}$th of a minimal lethal dose of diphtheria toxin into the skin. If the patient is not naturally immune, the skin surrounding the puncture becomes red, later scabs and brown pigment are formed going on to scaling; in those naturally immune, this reaction does not occur. The reaction in 95 per cent. of the subjects can be read accurately within 24 hours. The physician can at once separate the immune from the non-immune; attention is concentrated on the latter and any development of suspicious sore throat calls for the immediate giving of antitoxin.

The inmates who have given a positive Schick reaction are immunised with a toxin-antitoxin mixture which is not fully neutralised. Three injections are given at weekly (or shorter) intervals. The Schick test is again applied some two weeks later, when from 50 per cent. to 90 per cent. of those immunised will give a negative reaction and are protected against the occurrence of severe or fatal diphtheria. Those who still remain positive can be given one further injection and tested two to four weeks later, when most will have become immune. A small percentage of people are very refractory and do not become immune until after several repetitions of the treatment outlined above. Toxoid-antitoxin mixture is now also being used.

Study of School Influence—Numerous outbreaks of illness have been dealt with from time to time on the lines of the Memorandum of 1890—at first mainly in rural districts, but in more recent years, and particularly since increasing use has been made of the information afforded by notification certificates, also in towns. Sir Shirley Murphy repeatedly commented upon the extent to which school influence had operated in favouring the spread of scarlet fever and diphtheria in London schools. In 1891 and 1894 he had already noted the fact that there had been an increased incidence of diphtheria mortality in recent years upon the age 3 to 10 years, as compared with the incidence upon all ages. This new departure was more noticeable in London than in other parts of the country, and, having regard to the time of its appearance, was "suggestive of a fresh factor of diphtheria at ages 3 to 10 years becoming operative in the decennium 1871–80, the increased tendency of children from 3 to 10 years of age to die from diphtheria having manifested itself somewhere between the two periods, 1861–70 and

1871–80." A closer examination pointed "to the year 1871 as that in which this increased incidence first became conspicuous," and it was noted that "the Elementary Education Act first became operative in that year." The question as to how far altered nomenclature was responsible for the behaviour of the figures obviously required to be considered; it was found, however, that on inclusion of croup with diphtheria, similar results to those afforded by the diphtheria figures alone were still obtained.

Moreover, in 1894, Shirley Murphy called attention to the fact that the influence of schools, in giving opportunity for the communication of infectious disease from person to person, was being manifested in another way. "It might be expected," he said, "that any interruption in school life would be indicated by a diminution in the amount of prevalence," assuming that school influence was at that time operative. He was led to look, therefore, for "some evidence of the influence of longer holidays," and the existence of a "marked August holiday depression" was, as a result of his inquiries, demonstrated in the curves showing the cases of diphtheria and scarlet fever notified week by week.[1] But it was argued, "the closing of schools ought to be attended by some difference in the age-incidence of the disease, if it is associated with diminution in the amount of disease caught at school." On grouping the cases (of scarlet fever or of diphtheria) into three age-periods—under three years of age, above three years of age and under thirteen years of age, and above thirteen years of age—it was found that the children from three to thirteen years of age enjoyed a larger immunity during the holidays than did persons at other ages; in other words, the holiday depression was especially marked in the case of children of school age. It was noted that it was of course "possible that other influences, such as the migration of population from London," might have contributed to the August depression. To meet the requirements of the case, it would be necessary, however, to assume "that this migration was of very notable extent, and that children at school age migrated very much more largely than persons at other ages."

A further report in 1898 showed that in London, and in England and Wales generally, there had been a notable increase of relative incidence of diphtheria mortality on the ages 3–4, 4–5, 5–10, and 10–15. The extent to which this increased incidence might be attributable to changes due to differences in nomenclature, to changes due to actual behaviour of disease, or to changes due to some varying social conditions of the community, was then carefully considered.

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[1] The depression did not precisely correspond with the period of closure; thus it commenced about a week after the schools closed ("allowing two or three days for the incubation of the disease, two or three days for the disease to become recognised, and perhaps for a little delay in the notification"), and was most conspicuous in the four weeks terminating about a week after the schools had re-opened. Cases of typhoid fever showed no August depression.

As regards nomenclature it was felt that the only safe course to adopt, in considering variations in prevalence of diphtheria, was to group together croup and diphtheria deaths. The question of transference, from scarlet fever to diphtheria, also needed consideration in connection with the altered age-incidence of diphtheria ; here the figures were found to suggest that some such transference had taken place. The fact, however, remained, that " irrespective of all questions of change in nomenclature, there is increased incidence on the ages 3–4, 4–5, and 5–10, when the figures relating to diphtheria, croup, and scarlet fever are all combined." The hypothesis that this increase was caused by the aggregation of children at school appeared " most likely to be correct," and when careful study was made of the behaviour of other diseases (measles, scarlet fever, and whooping-cough), nothing was found which could be held to militate against this hypothesis.

As regards the August depression additional evidence, supplied by the figures available for more recent years than those previously dealt with, was now forthcoming, and it was clear that there was a close correspondence in point of time between the diminution of prevalence and the closing of the schools, allowance being made for incubation and a little delay in notification. It was further noticed that the depression in the curves relating to the age-period 0–3 generally occurs somewhat later than in those relating to the age 3–13, suggesting " a lessening of the infection of the younger by the older children."

Shirley Murphy concludes, as the result of his inquiry, that a substantial balance of the increased incidence, of diphtheria mortality, upon children at the school age, is due to " greater opportunity of infection at school," and he says : " This change in the age-incidence of mortality had its beginning about the time that compulsory attendance at school had its beginning, has affected the country as a whole, and has not only been maintained ever since, but has steadily grown in proportion until the present time. Examination of the figures supplied by the notifications of diphtheria points in the same direction. The very striking difference in the age-incidence of notified cases when schools are in operation, and when school attendance is suspended for the summer holidays, is in agreement with the hypothesis that the age-incidence of diphtheria mortality has been affected by attendance at school. Again, this behaviour of the figures supplied by notification, is not limited to those of London, but is shared by the figures of other large towns."

In connection with the investigation of school influence, it has been found, in some instances, that particular classes in the school have suffered to a disproportionate extent; again, in schools containing boys' and girls' and infants' departments, one of these departments only has been especially attacked. The infants' department, as might be expected, has been more particularly involved in numerous instances. Such limitation of disease to classes or departments of a school has, of course, important bearing upon the question of school closure. The increasing amount of attention which has been directed to the risk of spread of infectious disease by school operations has led to the system of periodical medical inspection of scholars being adopted in several instances. By this means cases of illness, which might otherwise not be recognised and might cause much mischief, can be detected and prevented from giving rise to further cases.

Dysentery—The term dysentery denotes a symptom—the passage of blood and mucus by the bowel. The diseases included under this heading have of late years been determined. Manson early pointed out that dysentery contracted in the East Indies is prone to eventuate in abscess of the liver, whereas this sequel is rare in the dysentery of temperate climates and certain tropical countries, *e.g.*, the West Indies. The obscurity was diminished by the discovery of the dysentery bacillus by Shiga, the differentiation of the Flexner type, and gradual acceptance of the part played by Entamœba histolytica in the causation of the form of dysentery liable to be complicated by liver abscess.

During the War examination of the stools of men taken ill with dysentery on the Gallipoli peninsula made widely known the large variety of protozoa associated with the malady; of these, however, apart from Entamœba histolytica, which stands out predominantly, only Lamblia intestinalis is of much importance. Bacillary and amœbic dysentery, however, can only be differentiated with certainty by bacteriological and protozoological examination.

During recent years several small outbreaks of Flexner and Shiga dysentery have occurred in this country. Examination of the stools for the bacilli and the power of the blood of sufferers to agglutinate dysentery bacilli, determine the nature of the outbreak. The Shiga bacillus forms a fairly definite type, the sugar reactions are usually constant and a bacillus agglutinating to the standard Shiga serum can be accepted. But the identification of the Flexner group is more difficult; Professor Dreyer has divided practically all of 116 strains into five races of strains, V, W, X, Y, Z, emulsions of which can be used for testing the agglutinating properties of the patient's blood.[1]

Dysentery is markedly influenced by season. In Europe it has prevailed, as a rule, in summer and early autumn. Soil has been held also to exert influence, and a moist and polluted subsoil has been supposed to specially favour its development. As regards means of entrance of the organism into the human body, water has recently been conclusively demonstrated to be a source of the Flexner form of the disease.

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[1] These can be obtained from the Standard Laboratory at Oxford.

An outbreak of dysentery in the Ogmore Valley, mid-Glamorganshire, in 1921, was of so explosive a character—700 cases occurring in the early stages of the outbreak—that attention was at once directed to the milk and water supply. A house-to-house inspection was made; no milk supply was found to be common to the infected houses; this cause was dismissed. Only three houses out of 36 visited in a small area supplied with water from an independent source, the Gorwyl spring, were attacked; one school child was found in each to be ill. In the other part of the town, west of the river, 308 out of 494 houses visited were attacked and on the east of the river 88 out of 385 visited. The epidemic was well established in the western side of the town prior to May 20th, when a case occurred in the eastern area. The main water supply is from springs and upland surface water at Nantymoel, and is filtered: it is supplemented by an auxiliary unfiltered upland surface supply from Fairy Glen, which supplies the larger part of the western area. The heaviest incidence occurred in houses situated nearest the supply. The three children in the Gorwyl area attended a school supplied with water from the Fairy Glen source. Bacteriological examination of samples of the water taken on different occasions at Fairy Glen, showed a high relative number of B. coli; evidences of recent human fæcal contamination were found by different observers during an inspection of the source. Examination of the serum and stools of the patients showed that the Flexner bacillus (W) was responsible; 15 patients died. In the later stages of the outbreak the infection was disseminated by personal contact: the sequence of events was that one house in a street became infected, and after an interval of several days other houses in the street were infected. Flies were not prevalent in the district till later in the year. The site of the intake was changed, the mains disinfected by chlorination, and children from infected houses excluded from school.

A small outbreak attributed to intermittent infection of milk by a carrier of Shiga bacilli and Flexner bacilli occurred at Lynton in 1922.[1] Eighteen patients belonging to eleven households were infected: four died. Multiple invasion occurred in five households, the spread being probably due to personal contact. The dairy foreman suffered from dysentery in 1918.

Flies are in all probability transmitters of infection in bacillary dysentery; dysentery bacilli have been recovered from flies two or three days after ingestion; the question as to whether some blood-sucking insect may be concerned in the matter has been raised.

Asylum dysentery is usually due to bacillary infection of the Flexner type; outbreaks due to the Shiga type which produces a more serious illness and is more fatal in its effects are very rare in asylums in this country. Occasionally during an outbreak of asylum dysentery, cases due to infection with paratyphoid bacilli or Morgan's bacilli occur closely resembling bacillary dysentery.

Amœbic dysentery is probably spread by intimate personal contact; no outbreaks due to milk or food have yet been recorded. Drinking water is held to convey the disease ; Allan reported a small outbreak of amœbic dysentery in North Carolina due to an infected well.[1]

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[1] Ministry of Health Reports on Public Health and Medical Subjects, No. 20.

Carriers possibly disseminate the disease, but the degree of danger of spread by amœbic infection in this country, if any, is still unsolved. Cysts of Entamœba histolytica are habitually excreted by a considerable number of people in the country, who have never been abroad, and who have not suffered from any form of intestinal disturbance. Until, however, it is decided that no pathological condition can be associated with the presence of histolytica cysts in members of our home population, it would be unwise to ignore the possibility of risk from the amœbic cyst carrier returned from abroad.

The possibility of bacillary dysentery being the cause of any sudden and severe gastro-enteritic attack, especially during the autumn, should be borne in mind. Polyvalent anti-dysenteric serum should be used whenever the clinical symptoms point to a definite or severe attack of dysentery without waiting for a bacteriological diagnosis.

The main points to be looked to, in connection with the prevention of dysentery, are water supply and the avoidance in institutions of insanitary conditions and overcrowding. Strict regard to cleanliness is necessary in the case of those brought in contact with the subjects of dysentery, and the stools and linen, etc., used by patients, should be carefully disinfected. In camps the proper disposal of excreta must be carefully looked to, as must also the prevention of the infection of food by flies. Flies must be kept under.

Encephalitis Lethargica (*Epidemic Stupor*, *Sleepy Sickness*) —The symptom-complex—fever, lethargy and ocular palsies—aroused much interest in 1918 shortly before the last influenza outbreak ; from 1919–23, the numbers of cases notified each year were 538, 914, 1,470, 454, 1,025, and during 1924, the number notified was 4,950.

The disease may take the form of general disturbance of the central nervous system without localisation or with various localisations in the central nervous system ; mild or abortive cases also occur.

In a severe case the most striking early symptom is progressive lethargy usually gradual in onset ; the patient becomes heavy and drowsy and headache, often frontal, is also a common symptom. On the other hand, extreme restlessness and sleepiness may be present. Giddiness and double vision frequently occur. The patient is especially averse to bodily exertion and after any effort soon becomes tired and fatigued. The speech is markedly altered, sentences are uttered very slowly, the words are slurred one into another and uttered hesitatingly, more rarely, after commencing by speaking in this way, so rapid is the flow of words that the patient is understood with great difficulty. Usually paralysis of the muscles of the eye occurs, causing ptosis, transient squint, and irregular movements of the eyeball ; weakness or paralysis of the muscles of the face is seen, slight at first but gradually ncreasing. The appearance and attitude of the patient is typical; he lies in is bed on the back, usually with the arms bent across the chest or abdomen, he face is quite expressionless and immobile so that he looks like a wax figure. witchings occurring in certain muscles are sometimes present; they are usually ery persistent. Transient rashes appear at times. All degrees of the disease owever are met with. In some cases altered behaviour may be almost the nly sign of the disorder—an ordinarily well-behaved person becoming irritable, nnoyingly talkative, or restless; in others lethargy and listlessness may serve lone to mark the existence of the disease, and the patient feel well enough o carry on his everyday life.

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[1] Allan J. Am. M. Ass., Chicago, 1909, liii, 1561.

"The non-recognition of *mild* but infective cases may often account for he apparent sporadicity of the disease, and in the investigation of any outreak of encephalitis lethargica it is very important to search for them among ontacts or elsewhere. Few such cases were observed during the 1918 prevaence, but subsequently their occurrence has been more frequently and definitely stablished.

"The symptoms presented by the mild cases are various. The persons found o be affected may have been in contact with a declared case of encephalitis ethargica, and certain of them whose symptoms are restricted to soreness or ryness of the throat, naso-pharyngeal catarrh, stiffness of the neck muscles, eadache, vomiting, or diarrhœa, can only be recognised by this association. ther patients display mild manifestations of the symptoms seen in the proromal period of the disease—slight lethargy or stupor (which may or may ot be present), mental apathy, headache, lack of facial expression. A short ebrile interval may occur or there may be transient loss of vision (the pupils eing dilated but insensitive to light), transient diplopia, transient facial paralysis r transient ptosis. It has sometimes appeared that outbreaks of 'epidemic iccup' may have been due to the infection of encephalitis lethargica."[1]

The diseases most commonly associated with symptoms resembling those f encephalitis lethargica are influenza, tuberculous meningitis, cerebro-spinal ever,[2] poliomyelitis, polioencephalitis, functional nervous disorders, hysteria, erebral thrombosis and the results of injuries to the head.

Ordinary cases present little difficulty in diagnosis, but the same annot be said of the disease in children, and of the mild or fulminating ases or those with transient symptoms ("abortive" cases). In hildren the disease is liable to be confused with tuberculous menngitis. Attention has recently been directed to the value of "followng up" and recording the after-history of patients; in particular, as to any mental after-effects which may be observed. In this connection inquiry should also be made into the previous history of children who begin to exhibit changes in behaviour or unusual accentuation of undesirable qualities; these symptoms not infrequently point to an overlooked attack of epidemic encephalitis at an earlier date. Other important sequelæ include the Parkinsonian syndrome, which closely resembles and may be identical with paralysis agitans, sudden shock like muscular spasms (myoclonus) of the limbs, diaphragm or larynx.

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[1] From Memo. $\frac{45}{\text{Med}}$ Revised of Ministry of Health on Encephalitis lethargica.

[2] An examination of the cerebro-spinal fluid is often useful in that it may assist to exclude this disease.

Instances of direct infection have been reported; Reece in 1919 recorded an instance where a nurse contracted the disease while attending a patient; in four instances in this country babies born while their mothers were suffering have contracted the disease.

In August, 1919, an explosive outbreak occurred in a home for girls in Derby; out of 22 inmates 12 were attacked within a fortnight; 5 died. The first two patients were probably infected from a common source—latent in the home itself or met outside, but it is likely that direct contagion was responsible for most of the illnesses. School attendance was responsible for the spread of the disease at Radway, in 1919. On September 15th, the first patient, found asleep at her desk, was roused with difficulty, and sent home. After a long week-end she returned to school, and attended regularly in spite of daily bouts of sleepiness and headache; subsequently, on October 9th, 11th, and 13th, three other girls were similarly attacked.

The comparative frequency with which the more striking examples of multiple infection occur in isolated districts, or secluded communities, suggests that the dwellers in populous centres, owing to constant contact with infection, acquire an immunity to the virus.

The relationship of encephalitis lethargica to other similar diseases is at present much discussed.

A question to be decided is whether apparently different clinical entities such as encephalitis lethargica, acute poliomyelitis, acute polioencephalitis, acute delirium of children, ascending and descending forms of Landry's paralysis (to which Levaditi would add rabies, herpes, vaccinia), are not in reality several varieties of poliomyelitis produced by one organism but of different type, or whether a different species of organism is not responsible for each of these clinical entities.

Our lack of knowledge of the relation of the viruses causing encephalitis is instanced by the results of the experiment of M. H. Gordon, who showed that the virus of mumps injected intraspinally can produce encephalitis as manifested both clinically and histologically. Again, about 1913, there were admitted into one of our largest hospitals a number of cases of acute delirium in children which rapidly proved fatal. A few foci of encephalitis were found on histological examination, but injection of suitable material derived from the cases into monkeys produced no results.

In Levaditi's study of the group of diseases, *ectodermoses neurotropes*, caused by ultra-microscopic viruses which attack tissues derived from ectoderm,—the cornea, skin, and the central and peripheral nervous system,—he demonstrates the existence of bodies included in the nerve cells of sufferers from encephalitis lethargica, analogous to Negri's bodies found in rabies ; this he considers forms one link the more in the chain of reasoning which goes to show that these diseases are very much akin. The virus of herpes, he holds, is a less virulent variety of the virus of encephalitis lethargica.

The doctrine that in the naso-pharynx resides the principal cause of contagion in encephalitis lethargica (and poliomyelitis) and that this cavity must be treated if we are to prevent spread of the disease, has been widely accepted.

Levaditi claims that his experiments demonstrate that the saliva of healthy carriers can set up encephalitis lethargica in animals ; it is doubtful whether vaccination can produce immunity.

In view of the frequent severity of the disease and the importance of skilled nursing most cases should be removed to isolation hospitals. If kept at home the patient should be isolated in a separate room and any association limited to what is necessary for his proper care and nursing.

School children in the affected household may be kept from school, as a precautionary measure, for three weeks after the isolation of the patient. There is no necessity to place restriction on the movements of other occupants provided they are frequently examined and remain well. Those in contact with the case, however, might be advised to use suitable antiseptic nasal sprays or douches and to gargle the throat.[1] Any persons in the infected household who suffer from sore throat or other symptoms suggesting an abortive attack should be treated from this point of view and isolated as far as possible until they have recovered. The sick-room should be thoroughly cleansed and disinfected at the end of the illness.

Erysipelas—This disease has been known since early times ; it occurs all over the world, but only comparatively infrequently in the tropics. In England the average death-rate per million living has not greatly varied during registration times, though it has shown some tendency to diminish in recent years. The close correspondence between cyclical manifestations of high mortality from erysipelas and from puerperal fever, the relation observed between those cycles and periods of high mortality from certain other diseases, and their inverse relationship to periods of excessive rainfall, have already been referred to. Hirsch pointed out, as regards puerperal fever and erysipelas—that the two diseases often [used to] prevail coincidently in lying-in institutions ; that women in labour who have been attended by persons suffering from erysipelas or in attendance on erysipelas patients have taken puerperal fever; conversely, that doctors, nurses, etc., and new-born infants, associated with puerperal fever, have developed erysipelas; and further, that puerperal fever sometimes appears, as it were, "to develop from an erysipelas which mostly arises in the lacerated vaginal mucous membrane."

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[1] For example, any of the following :—

(1) One per cent. solution of peroxide of hydrogen.

(2) A solution of permanganate of potash, 1 in 5,000, in 0·8 per cent. solution of chloride of sodium (common salt).

(3) Liquor sodæ chlorinatæ, 0·5 per cent.

St. Clair Thomson, however, declares against their use.

Erysipelas is more fatal in the colder months, and its seasonal curve corresponds fairly closely with that of puerperal fever. Apart from newly-born infants in whom infection may take place at or near the navel, most cases occur within the ages of 20–60 years; the incidence increases with age. Alcohol and poverty are predisposing causes.

The organism associated with erysipelas was isolated by Fehleisen, who named it the streptococcus erysipelatosus, now held to be identical with streptococcus pyogenes; it can be cultivated, and by inoculation of the material obtained from cultures, erysipelas can be produced in rabbits.

A short-chained type, streptococcus fæcalis, can also produce erysipelas. If these organisms attack the superficial structures erysipelas is produced, if the lower cellulitis; suppuration may occur.

The disease is probably always induced by inoculation, though the abrasion may be microscopic. Cases in which the site of introduction of infection was not apparent were denominated at one time "idiopathic," to distinguish them from the ordinary "traumatic" erysipelas.

The incubation period is generally three to eight days. An attack of the disease appears rather to predispose to, than to protect against, subsequent attacks; perhaps the more correct interpretation of the facts observed would be to say that some persons appear especially prone to be attacked by the malady. Outbreaks of erysipelas—for example, that at the Radcliffe Infirmary, investigated by Netten Radcliffe—have been associated with drainage emanations. There can be no doubt that the occurrence of erysipelas in hospital wards has been materially controlled by the improvement of hygienic conditions and the strict enforcement of cleanliness.

Fomites retain infection for some time; infection can be carried on the hands and instruments of attendants on erysipelas patients. Infection lasts until all desquamation has ceased.

When occurring among people of cleanly habits, living in fairly hygienic surroundings, the disease rarely spreads. Epidemics, however, occur from time to time where these conditions do not hold.

It is the usual practice in hospitals to separate cases of erysipelas from clean operation cases and puerperal women. When notified, the dwelling should be examined in order to detect any sanitary defect. The mattress should be disinfected lest it should give rise to puerperal fever if used by a woman during and after childbirth.

Glanders, Farcy (Latin, *Malleus* or *Equinia*)—This disease has been known in horses since ancient times; the fact that it is contagious appears to have been first recognised in the seventeenth century. In 1882 the *Bacillus mallei* was shown by Löffler and Schütz to be the cause of the disease. Glanders is widely distributed throughout Europe, and occurs in parts of North and South America; cases have, of late years, been reported from South Africa and from the East Indies. It occurs in the horse, mule, and donkey, and is in rare instances communicated to other animals and to man, usually by direct infection from nasal discharges, inoculation occurring through a scratch on the skin. Nocard regards the intestinal tract as the chief site of entry of infective material in horses; cats and lions and tigers in menageries have been infected by eating the flesh of glandered horses. Washerwomen have contracted the disease by washing the clothes of a patient.

In the horse the incubation period is from three to eight days. Nasal discharge appears a day or two after the onset of the malady, and in acute glanders the disease reaches its height rapidly, the nasal mucous membrane becoming extensively ulcerated, the submaxillary glands enlarged, and the lymphatics of the face "corded" (farcy); the lungs generally become affected by metastasis, and dyspnœa and death from suffocation speedily supervene. In farcy the characteristic appearances are due to inflamed lymphatic vessels, which can be felt as cords and nodules ("farcy buds") beneath the skin. In chronic glanders the onset is insidious; cough, enlarged glands, and other symptoms may precede the development of nasal discharge, and corded lymphatics may be noted in connection with affected parts. The disease may last for months or years.

Glanders in the human subject is most commonly found amongst grooms and others who work among horses; even among them it is a comparatively rare disease. Infection occasionally occurs in the laboratory from handling cultures of the glanders bacilli. The number of deaths due to glanders each year is now very small.

The usual incubation period is three to eight days, but it may extend to three weeks. Headache, "rheumatic pains," œdematous swellings, an inflamed condition at the site of inoculation, and gastro-intestinal symptoms may be noted. Nodules which subsequently break down and ulcerate may appear under the skin, and the nasal mucous membrane may also be affected, though this is less frequent than in the case of the horse. The lungs are usually involved, and œdema of the glottis may supervene. The chronic form of the disease is characterised by a local granulomatous condition which usually breaks down and gives rise to an ulcer; swellings of the joints may occur; it is rarely met with in the human subject.

The diagnosis of glanders in horses has been facilitated by introduction of the "mallein" test; when injected subcutaneously a reaction, with rise of temperature (1·5° to 2·5° C.), persisting for twenty-four hours or more, is in the case of glandered horses produced by doses which have no appreciable effect on healthy animals. A reaction is sometimes observed, however, in animals which are the subject of disease, but which are not glandered. The ophthalmic form of the test is more convenient; when mallein is dropped into the eye a positive reaction is manifested by a purulent discharge and swelling of the eyelids. No single test, however, is adequate. The Straus test consists in inoculating a male guinea-pig intraperitoneally with suspected pus, gland juice, or nasal discharge; characteristic orchitis is, as a rule, set up in the guinea-pig if glanders be in question.

The agglutination test is of value in cases of recent infection. The complement fixation test of Schütz and Schubert is the most reliable method of diagnosis available at present for horses. In man diagnosis should be made by culturing the organism from lesions and inoculation of a guinea-pig.

If glanders is present in a stable, all diseased animals should be destroyed, and those apparently healthy should be isolated and tests applied. The carcasses of slaughtered animals must not be cut up, but should be destroyed by fire, or treated in a digester, or, if this is impracticable, they should be buried at least six feet beneath the surface of the ground, and covered with quicklime. The stables, harness, troughs, buckets, etc., should all be thoroughly disinfected; the common drinking trough in streets must also be disinfected. The bacillus of glanders is readily destroyed by bleaching powder. Men working with infected or suspected horses should wear rubber gloves and disinfect their hands on leaving work.

An Order of the Board of Agriculture of 1892 provided for compensation on slaughter, and gave powers for securing examination of horses and for enabling local authorities to dispose of infected carcasses. A Departmental Committee reported on glanders in 1899 and recommended—that notification of the disease should be obligatory upon veterinary surgeons, and upon owners of knackers' yards in the event of glandered animals being taken to their premises for slaughter; that the slaughter of animals showing clinical symptoms of glanders should be made compulsory; and that compensation for horses slaughtered, solely on account of reaction to the mallein test, should be on a higher scale than in the case of horses presenting clinical symptoms of the disease.

Glandular Fever—Glandular fever is an acute infectious disease without any rash, characterised by acute inflammation affecting lymphatic glands, usually the cervical, but also other groups without any obvious lesion of the mucous membrane or skin drained by the lymphatics going to the glands concerned; in the case of the throat, however, slight redness is seen and the patient may complain of a soreness. If suppuration of the glands occurs it is probably due to secondary infection. Although sporadic cases are occasionally seen, the disease usually occurs in small epidemics affecting the children of a single household, but it has been widespread, as, for example, when by reason of failure to diagnose the disease, sufferers have been allowed to return to school while still infectious. Few children between the ages of 2 and 14 years escape if exposed to infection; adults are occasionally attacked.

After a period of incubation varying from five to fifteen, but usually of six or seven days, the child suddenly becomes ill and holds his head stiffly. The temperature is raised (101°–103° F.); nausea is present; the tongue is furred; at times, vomiting and constipation occur. Pain is felt on swallowing. Large swellings, visible from a distance, rapidly form on one side of the neck; on palpitation these are found to be the anterior cervical lymphatic glands and are usually, but not always, somewhat tender; the temperature falls to normal. Another attack of fever may suddenly occur coinciding with enlargement of the glands on the other side of the neck. Later other groups of glands in the body, *e.g.*, the axillary and inguinal, may similarly become enlarged; abdominal pain probably signifies enlargement of the mesenteric glands. The spleen is enlarged in half the cases; no anæmia is present.

Relapses may occur, but the considerable majority of the patients rapidly recover, although the glands are palpable for several weeks or months. In about 6 per cent. of the cases, hæmorrhagic nephritis occurs. The mortality is negligible.

The disease is apparently identical with infective mononucleosis and acute "lymphatic leukæmia with recovery."

Influenza—Hirsch says this disease "may be followed into the remotest periods from which we have any epidemiological record at all," and he gives a list of epidemics which have been observed in various parts of the globe, from the twelfth century onwards. In England the malady was prevalent during the last century, and outbreaks occurred in 1803, in 1833, and in 1837–8. During the early years of the period of registration considerable numbers of deaths from influenza were recorded; thus there were over 1,000 in 1840 and in 1841. In 1847–8 the disease was much more widely prevalent; indeed, in the latter year the mortality was nearly 8,000. From this time onwards until 1860, more than 1,000 deaths were registered in each year, while in 1851 the number was 2,000, and in 1855 the number 3,500 was exceeded. Thus, following upon the 1847–8 outbreak, came a series of years of marked though lessened influenza mortality.

After 1860 the influenza deaths did not again exceed 1,000 in any one year until the commencement of the pandemic commencing in 1889 and 1890. During the " sixties " and " seventies " the mortality was notably diminished; occasional slightly marked exacerbations were, however, observed. During the " eighties " the number of deaths recorded was comparatively trivial, and possibly a con-

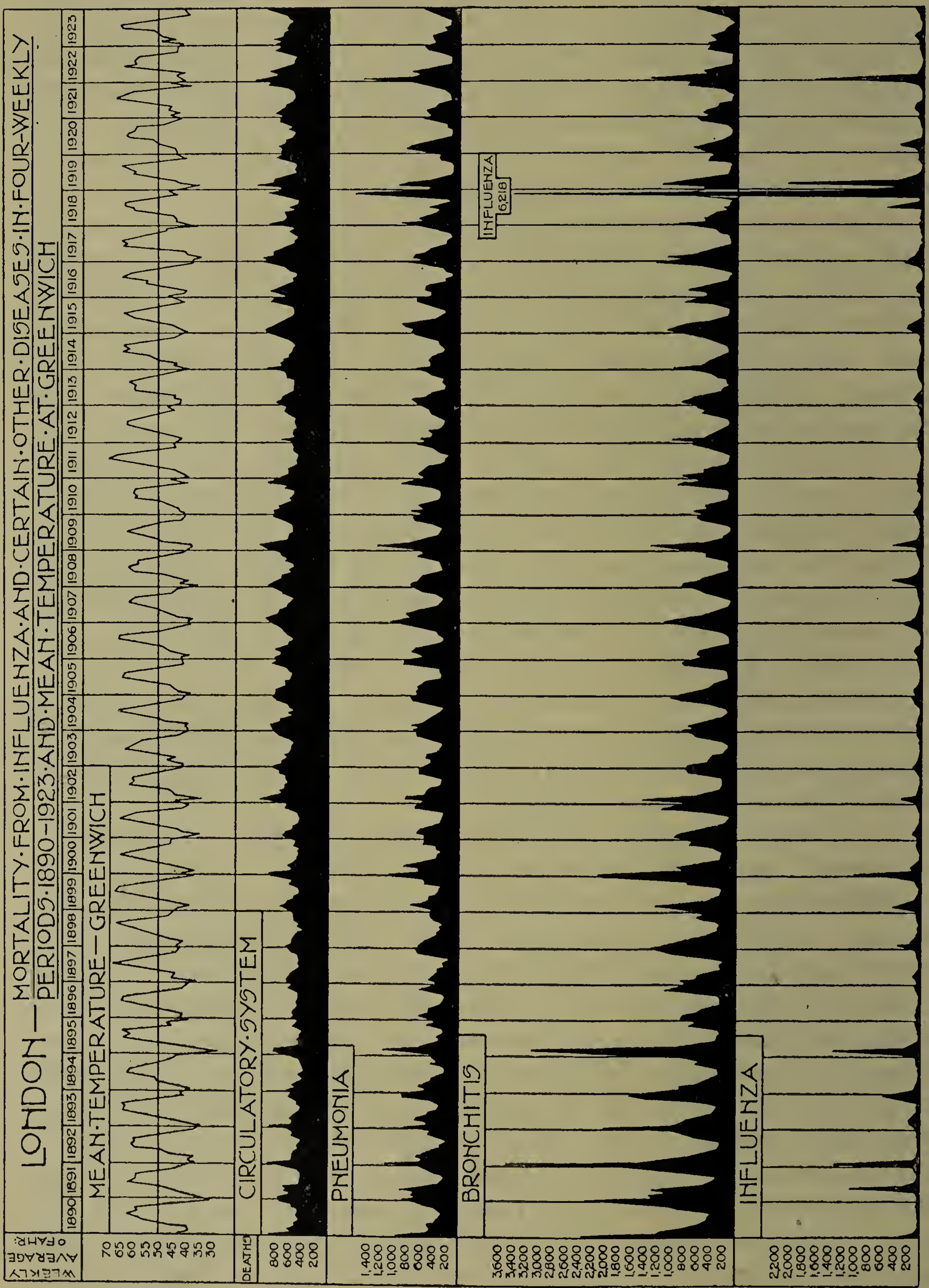

FIG. 78.

derable number of these were not really due to influenza at all. n the first year of the great epidemics of the “ nineties ” 4,523 deaths ere registered ; in 1891 the number amounted to 16,686 ; in 1892 iere was again high mortality ; there was evidence of abatement i 1893 and 1894 ; but in 1895 the deaths were in marked excess ; ie two following years again showed diminution. The closing years f the century were years of high mortality, the deaths recorded in 900 being not far short of the number registered in 1895.

All known outbreaks were far surpassed by that of 1918–19, hich caused 3,129 deaths per million living in England and Wales i 1918, and 1,170 per million living in 1919. The pandemic f 1889–92 revealed for the first time the disease in successive waves, eparated by short intervals ; the disease was probably imported from ussia ; Franklin Parsons in his report showed that influenza has n almost world-wide distribution, and appears to be practically ninfluenced by race, soil, climate, season or weather. He pointed ut that in passing over the northern hemisphere the epidemic waves f influenza have travelled, as a rule, from east to west ; they have. ioreover, spread along the chief lines of human intercourse, and have ot travelled faster than human beings could travel. In each country ie disease “ has appeared first in the capital, or the ports of entry, r the frontier towns in communication with countries previously ivaded.” The persons brought much in contact with others have een the first to suffer, and the disease has specially prevailed in istitutions and in large establishments, where considerable numbers f persons are collected together. Hence Parsons concludes that ie disease is “ propagated mainly, perhaps entirely, by human itercourse.” As he remarks, however, it is not to be denied that ie contagion, once imported into a locality, may propagate itself itside the human body. The causes which determine the reawaken- ig of the disease into activity after it has spent its first force in any articular place are not understood.

The *case-mortality* of influenza is difficult to gauge. Parsons found i 1890 that 1·6 per 1,000 of the patients treated for influenza at eight irge London hospitals died. The mortality returns show that during ears when deaths returned as due to influenza are in excess, those scribed to pneumonia and bronchitis, and to some other diseases, lso show increase, and there can be no doubt that many of these eaths are really due to influenza. See Fig. 78. The case-mortality of he three waves of 1918–19 in a portion of the population in Manchester as 0·71, 2·75, and 2·66 respectively. Although the fatality is low i epidemics, the disease is so widespread that the number of deaths very large. The last pandemic caused more deaths in the world han the five years of war.

The comparative escape in 1918–19 of persons who had suffered severely in the epidemics of the "nineties," has been held to show that a lasting protection may be afforded to those who have again and again been exposed to infection. A statistical investigation of those affected in the several waves of the epidemic also showed that on those who were attacked in the first wave, a measure of protection against the later waves was conferred.

In the 1918–19 epidemic the first wave, June and July, 1918, was one of the three-day fever type; young adults aged 15–35 years were especially attacked. The second wave, October and November, 1918, ushered in much more severe forms of the disease with bronchopneumonia or virulent toxæmia; a third wave in February, 1919, was composed of rather severe cases. After nine months' quiescence, in February, 1920, a fourth wave occurred with relatively few deaths, attacking as in pre-epidemic years children and old people.

The pandemic struck both those living under sanitary and insanitary conditions; no evidence was forthcoming to show that domestic overcrowding was an important factor in the spread.

As regards the relation of influenza to other contemporary diseases, Newman holds that various epidemiological records go far to establish that the epidemiological features of the cycle of years within which influenza explodes are different from those of the influenza-free cycles, in that preceding epidemic influenza there is often a rise in general morbidity of the population, an "epidemic constitution" develops favourable to influenza, there are early though often mild and atypical clinical forerunners of the disease, and parallel or allied clinical maladies are seen and that there are concurrences, similarities, and inter-relationships between outbreaks of cerebro-spinal fever, poliomyelitis, and outbreaks of influenza, bronchitis and pneumonia.

He goes on to say: "Taking into consideration the data furnished in this report (of the Ministry of Health on the pandemic of influenza in 1918–19) we may hazard the view that the recent visitation—its character and degree as well as its age-incidence—was due to the operation of an exalted virus (possibly an infecting agent, parasite or saprophyte, the virulence of which had been increased by human passage) or an unusual infection of associated or symbiotic organisms, the potential virulence of which had for many months, perhaps years, been rising to a critical and stable level. This specialised agent acted upon the adolescent and adult human tissues, which had an inherent susceptibility of response to its toxic effects engendered by a complex of factors—lowered vitality or resistance owing to strain, exposure, deprivation, or physical disability; or a virginity of tissue soil to the particular infecting agency; or the unsuspected carriage by sick or healthy persons of saprophytic or benign organisms awakened to pathogenic virulence by the infecting virus; or tissues rendered susceptible or vulnerable by the influence of other organisms. Social factors no doubt played a part in preparing the infecting seed or the soil, and in bringing to the critical and dispersive point the conditions which had hitherto been sporadic and restricted. Among these we must in particular include the extra-domestic aggregation of persons."

The most important lesson of the outbreak is the essential solidarity of all mankind in the matter of epidemic disease. If anywhere in the world there are large collections of men in depressed circumstances through war, revolution, or economic strife, there will be opportunities for such a modification of the materies morbi, which makes it able to spread all over the world. No land quarantine has ever yet succeeded. The material well-being of a foreign, even a hostile country, is a pressing concern to all other lands. Pfeiffer in 1892 discovered a bacillus which is very often present in the sputum, but it has also been found to be present in other conditions than influenza. It can be cultivated on artificial media.

Pfeiffer's bacillus is toxic for animals, but specific influenza has not been truly reproduced in them. Although as a primary cause it is not wholly out of court, it would seem more probably to be a secondary infection, responsible with the hæmolytic streptococcus for the abnormal fatality of the last pandemic.

It is considered by some authorities that influenza is due to an ultra-visible virus. An organism given the name of Bacterium pneumosintes has been described in America which is believed to be the initial infecting agent in epidemic influenza; it has the property of increasing the invasive potency of certain bacteria, including Pfeiffer's bacillus, pneumococcus and streptococcus.

It has been held that a disease known as "pink eye," which affects horses, is really influenza, and domestic animals have been observed to be attacked concurrently with the appearance of the disease in a household; but nothing is certainly known concerning influenza in the lower animals. Influenza is spread by the secretions of the respiratory passages and lungs. By coughing, sneezing or even loud talking these are sent out into the air in the form of a fine spray; the danger limit for loud talking is 4 feet, for sneezing or coughing 10 feet. The organisms are probably also borne by currents of air for short distances. Infection can be carried by the hands which have been soiled by secretions from the nose or throat of an infected person; the soiling is usually caused by handling a used handkerchief. The incubation period is about 48 hours.

In addition to the ordinary mild type of influenza, the febrile and respiratory types seen in this country, gastro-intestinal and nervous types also occur. The ordinary preventive measures cannot be applied to influenza; during epidemics large numbers of persons are attacked, and of these a considerable percentage are adults, many of whom are unwilling even to submit to confinement to the house. Whole households may be suddenly stricken down, and to carry out complete isolation is altogether impracticable. Some advantage may accrue from isolation of early cases, especially as the disease is most infectious at its onset; confinement to bed is indicated, as a rule, in the interest of the patient, even if it serve no good purpose in checking spread of the disease.

The sputum should be carefully collected and destroyed. Those attending the sick are advised to wear face masks of gauze or butter muslin over the mouth and nose, and to be inoculated with a standard vaccine. The period of isolation suggested is 10 days in mild cases, three weeks in severe cases. General preventive measures are thorough ventilation of meeting-places and conveyances and keeping fit.

Jaundice—Jaundice in epidemic form, and apart from other diseases, such as malaria, is definitely known to have existed since the latter half of the eighteenth century, the first described epidemic being either that in Minorca, variously dated as in 1745 or 1775, or one in Bremen in 1760.

After 1850 it was frequently noticed both in Europe and America, and in 1886 Weil, in Germany, differentiated a type of the affection (now known as Weil's disease). Cockayne,[1] reviewing epidemics of jaundice, concluded that in addition to Weil's disease, another specific disease, catarrhal jaundice, occurred in epidemic form, of which simple catarrhal jaundice was the sporadic form; he considered that the great majority of cases of acute yellow atrophy of the liver was caused by the same (unknown) organism.

In a paper read in 1914 [2] C. R. Gibson divided forty epidemics which had occurred in this country, chiefly in the autumn, into a larger group comprising 34, in which the incidence was almost entirely on children of school age, the number being small, varying from five or six to about 40.

In the other six outbreaks, the numbers affected were usually larger and adults between 20 and 30 years old were chiefly attacked.

In six epidemics occurring in Cheshire from 1911–14, 121 persons were affected, six of whom were adults, the remainder being children, practically all of school age. The illnesses were slight, as a rule, the child not usually being confined to bed; no deaths occurred. In most instances, where both sexes were equally exposed to the epidemic, females suffered more than males.

Of the 121 persons affected, 52 were single cases, 38 were in pairs, 18 in threes, 8 in fours, and there was one instance of five children from the same house being attacked. This incidence displays a far greater number of multiple cases from one house than is possible on random distribution, and the cause of this multiple incidence can only be home contact. School contact in all probability plays a considerable part in the spread. In four of the six epidemics investigated by Gibson the children affected almost without exception attended one school. At these schools from 12 per cent. to 45 per cent. of the children were attacked, the average being 23 per cent.

Owing to the gradual onset in many of the cases the incubation period was difficult to fix; the duration of infection was also difficult to determine, but there seemed grounds for believing that the infection is most marked usually in the first week or fortnight.

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[1] See "Quarterly Journal of Medicine," October, 1912.

[2] See "Public Health," March, 1914.

Weil's Disease or infective jaundice was proved in 1915 by Mada and other Japanese workers to be due to a spirochæte which they also found in the kidneys of field mice, and to which they gave the name Spirochæte ictero-hæmorrhagiæ. Before this discovery the occurrence of the disease in members of the same family and groups of soldiers in barracks had been observed.

The disease is characterised by gastro-intestinal disturbances, irregular pyrexia, and often severe jaundice, which usually appears about the fourth day of the illness and may become very marked; in severe cases bleeding from various mucous surfaces and into the tissues occurs with hæmorrhagic herpes and albuminuria. Mild cases cannot be distinguished clinically from ordinary catarrhal jaundice.

The fatality in Japan is about 40 per cent., but on the French and Italian fronts during the late War was only from 2 per cent. to 3 per cent. An outbreak occurred in East Lothian in 1924, chiefly among miners; 14 persons were infected, 4 of whom died. The organism was seen in emulsions of the kidney of a surface rat and a pit rat.

The presence of the spirochæte in house and field rats does not invariably set up disease in these animals. The organisms are passed in large numbers in the urine and fæces of the infected animals, contaminating the soil and even food. Infection in man takes place through the skin or alimentary canal; the cooking of food suffices to kill the infection. Swimming pools in the poorer parts of Paris are supposed to have been responsible for the spread.

Leishmaniasis ("oriental sore," kala-azar) is due to localised or general infection of man by a microscopic animal parasite of the genus Leishmania.

The localised form "oriental sore" is non-fatal, the generalised form kala-azar very fatal. The parasites were discovered in spleen pulp and later seen in blood from a splenic puncture. Parts of India are heavily infected; in Brazil of a population of 46 millions some 1½ to 2½ million are infected. The mode of transmission has not yet been discovered. Intravenous injections of salts of antimony usually bring about a cure.

Leprosy—This disease is known to have existed in Egypt, India, and China at a very remote period, but it would appear to have been introduced into Greece after the time of Hippocrates, and it was not well known in Europe generally until the end of the seventh century A.D. It had spread widely before the end of the eleventh century; hence the notion that it was introduced by returned Crusaders. "Leper-houses" were extensively brought into use in the twelfth, thirteenth, and fourteenth centuries. The diminution in prevalence of leprosy in Europe, in the centuries succeeding, has been attributed to this practice; Koch speaks, for example, of the "rigorous isolation in the numerous leper-houses," and says, "the consequence was that leprosy, which had spread to an alarming extent, was completely stamped out in Central Europe."

The disease did not finally[1] disappear from Great Britain until the end of the eighteenth century. It is still met with in Norway (where, however, the number of lepers has decreased from 2,833 in 1856 to about 170 in 1921) and Sweden. There are still over 7,000 lepers in Europe; South Russia, the Baltic Provinces and Crete each contain 1,000, and Turkey, Roumania, Spain and Portugal from 400 to 600 each. Throughout almost the whole of tropical Asia the disease is prevalent; in China there are 1,000,000, India and Japan each contain 100,000, and Siam and Indo-China each 15,000 ; it is widely distributed in the African Continent, especially in the tropical central areas, and occurs in South Africa, Madagascar, Mauritius and Réunion; the east side of South America, especially Brazil, is more severely affected than the west side. North America is comparatively free from the disease. In the Sandwich Islands and New Caledonia leprosy seems to have been unknown until recent years; once introduced it spread widely. Damp climates, especially if also hot, favour the prevalence of leprosy.

As regards the distribution of the varieties of leprosy, nodular or skin leprosy, "lepra maculo-anæsthetica" or nerve leprosy, and the "mixed" form, it has been suggested that climate has influence, nodular leprosy being more common in cold, damp climates, and the nerve form in warm or dry climates. Another theory attributes differing manifestations of the disease to variations in the number of bacilli present. The incubation period of leprosy is said to range from two to ten years. The disease is rare in young children, and in most instances commences between 10 and 30 years of age. Sex and occupation seem to have no special predisposing influence. The malady was generally held in former times to be hereditary, but there is no evidence that such is the case, indeed, in the light of modern knowledge, this supposition is exceedingly improbable.

Hansen's discovery of the *Bacillus lepræ* materially changed the point of view as regards leprosy. The bacillus is universally present in the disease, and absent in persons free from leprosy; it resembles somewhat in its appearance, and in being "acid-fast," the tubercle bacillus, but differs from the latter in certain points of detail as regards staining (it takes, and also parts with, carbol-fuchsin more readily), and as regards its arrangement and appearance in the tissues; moreover, it grows with difficulty on artificial culture media, and the results of inoculation of animals are markedly different. The fact that the leprosy bacillus cannot be readily cultivated in artificial media or in animals makes it impossible to apply the tests prescribed by Koch.

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[1] Since 1914 a number of cases have been isolated at St. Giles Homes (accommodation for 6 patients), near Chelmsford, Essex; the approximate number of cases of leprosy in this country are under 100.

It has been claimed that leprosy has been inoculated in man, but the evidence in the one case in which symptoms have developed subsequent to inoculation is not at all conclusive, as the man had lived among lepers, indeed, members of his own family were affected. The results of inoculation have in other cases been entirely negative.

Various kinds of food, and particularly fish, have been held to cause leprosy, but conclusive evidence is still not forthcoming under this head. The general opinion, nowadays, is that leprosy is communicated from person to person by contagion, and certain concrete instances supporting this conclusion have been recorded ; for example, a case of the disease occurred in Dublin, and the patient had never been out of the United Kingdom, but had occupied the same bed as his brother, a leper, and had frequently worn his clothes ; five years contact occurred before leprosy developed.

But even with intimate contact infection is rare ; in Japan 7 per cent. of children of lepers contract the disease, 3·83 per cent. of those married to lepers and 2·73 per cent. of people living in the same house with lepers. Children and adolescents are much more susceptible to infection than other persons. Nodular leprosy is much more infectious than the anæsthetic form.

The long incubation period spread over years makes it difficult to determine the exact mode of transmission. The abundant use of soap is thought to prevent infection ; this would point to the possibility of infection taking place as the result of continuous contact with a skin surface more or less abraded possibly by the activity of biting insects.

In the existing state of knowledge isolation in colonies must be regarded as an important means of prevention, but during the first few months or even years of the disease, infective lepers, often with no easily recognisable visible signs of the disease apart from a medical examination, may be discharging innumerable leprosy bacilli from their respiratory tracts when coughing, sneezing or even when speaking.[1] Lepers should not handle food supplies, sell in the street, beg or associate with children. The Third International Scientific Conference on Leprosy recommended that lepers should not be admitted to another country ; that in countries with but little leprosy isolation in a hospital or at home, if possible, should be practised, as in Norway [2] ; that where leprosy is endemic, isolation should be more rigorous and while the leper should not be separated from his family, infants should be separated from their parents at birth and kept under observation; also members of the family of lepers should be examined periodically. In India and China the difficulties, financial and other, of isolation on a comprehensive scale have not hitherto been surmounted. Treatment is also a key to prevention; the attraction of a successful method of treatment will do much to secure treatment in the earlier stages of the disease.

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[1] See "The present position of leprosy prophylaxis," L. Rogers, "Journal of State Medicine," December, 1923, p. 569.

[2] In Norway compulsory powers exist to isolate in hospital any patient with leprosy : this is usually exercised in the case of the more infective nodular form, but home isolation is permitted under close medical supervision if the home conditions are suitable.

The intramuscular injection of whole chaulmoogra oil, camphorated, has reduced the mortality in a Korean Leper Asylum from 25 per cent. to 1¼ per cent.; better results are claimed, especially in early cases, for the intravenous injection of the ethyl esters of chaulmoogra or hydnocarpus oils at Ditchpalli, India, where in nodular cases the treatment may be limited to the administration of an auto vaccine, or combined with the use of esters as above. Sodium gynocardate has also been used with success elsewhere.

Rat Leprosy—a disease of the grey rat (Mus norvegicus) found so widely distributed as Odessa, Berlin, London, Paris, Sydney, San Francisco, Japan and India, is not generally thought to be communicable to man although it closely resembles the human disease. Recently the human leprosy bacillus has been injected into rats and the morbid changes produced are said to show no macroscopic or microscopic deviation from those associated with spontaneous rat leprosy.

Malaria. See page 458.

Measles (Morbilli)—This disease appears to have been known to the Arabian physicians. Hirsch concludes that it was "in all probability widely diffused over Asiatic and European soil during the Middle Ages," and, as he notes, it has retained that position in the centuries following. It has, no doubt, been often confounded with other eruptive maladies, notably small-pox and scarlet fever. "At the present day," says Hirsch, "the area of its distribution may be taken to extend over the whole habitable globe." It has prevailed in epidemic form, though at long intervals, in outlying parts of Europe. (In the Faroe Islands in 1781, 1846, 1862, and 1875; in Ireland, 1664, 1694, 1846, and 1868; and also in Lapland.) Accounts relating to it have been received from all parts of Asia and Africa, concerning which knowledge as to the distribution of disease is forthcoming, and as colonisation has progressed in the Western Hemisphere and in Australasia, so measles has spread. In England and Wales the average annual death-rate, taken over periods of five years, from measles, since 1838, has varied from 539 (1838–42) to 205 (1916–20) per million living.

Periodicity.—Whitelegge traces "major waves" of prevalence of measles (as distinguished from "minor waves," extending over long periods of years. See page 375). He found that in this country, a maximum occurred somewhere about 1815; the succeeding minimum was probably reached in the early "thirties"; another maximum occurred in the early "forties," another in the "sixties," and yet another in the "eighties." He therefore suggests that there may be cyclic variation "in the quality of measles itself." Ransome found that in Sweden measles assumed widespread epidemic form every six or seven years, an interval which, as Whitelegge says, "is intermediate between the two classes of waves which we meet with in England." But in Sweden the population was sparsely distributed, and in scattered populations the phenomena might be expected to differ from those observed in thickly inhabited localities.

Hirsch gives the periodicity of epidemic recurrence for a number of places. In England "minor waves" occur, as a rule, at intervals of from eighteen months to two, three, or four years. It is a common experience to find, in the case of a particular town, that years of high mortality alternate with years of low mortality, and even when this sequence of events is not clearly exhibited on study of annual figures, it sometimes becomes apparent, as Whitelegge has pointed out, when the deaths are taken out in quarterly instead of annual periods. These "minor waves" are doubtless due in the main to accumulations of susceptible children, and "among the conditions tending to shorten the interval between successive epidemics are density of population, facility for close contact between infected and uninfected children at school and elsewhere, and certain meteorological states." On the other hand, the interval would be lengthened by "sparsity of population, scanty intercommunication especially among children, precautions as to isolation, and unfavourable states of weather."

Fatality—The case-mortality at Burton-on-Trent was found to vary from 1·5 to 3·5 per cent. in the years 1894–1900. In Lancaster, 1889–96, Theodore Thomson reported 138 deaths to 4,387 cases, a fatality of 3·1 per cent. In this country the fatality rarely exceeds 10 per cent. (Whitelegge, "Transactions of Epidemiological Society," 1892–93). Whitelegge has pointed out that at Sunderland, at Hanley, and at Barnsley there occurred a succession of outbreaks, reaching their maximum destructiveness in 1885, in 1889, and in 1891 respectively in these three towns; the evidence, moreover, he says, indicates that "severity of type" accompanied the increase in recorded mortality. Examination of the statistics of a large number of towns yielded "abundant examples of tolerable regularity in periodic explosions, but very few unmistakable evidences of cyclic changes of the kind now in question."

The high fatality observed in some outbreaks occurring during wars or in uncivilised lands was probably due to the almost total lack of nursing and medical care, the patients being either without appropriate food or any food at all.

When measles has been newly imported into communities previously free from it, a high fatality usually occurs, possibly due to the absence of the protection which it is suggested is transmitted to some extent from generation to generation in communities among which the disease is prevalent.

Other special circumstances may have to be taken into account. The number of susceptible children may be large.

In Sunderland, for example, during the years immediately preceding the great epidemic of 1885 the number of births was in notable excess ; the average for the decennium 1881–90 was about 5,818, but the number of births steadily increased during the early "eighties," and in 1883 and 1884 the births were 6,102 and 6,349 respectively. A like variation, though a much less marked one, occurred in Barnsley just prior to 1891. Again, the interval which has elapsed since the last epidemic materially influences the extent to which opportunity has been afforded for susceptible units to accumulate.

Influence of Season—The seasonal curve of measles is remarkable inasmuch as it may present two maxima and two minima. The annexed figure shows that in the years 1841–1900 the winter maximum was the greater of the two ; in the curve originally given by Buchan and Mitchell for the years 1845–74, this difference was accentuated. Davidson refers to the alteration in question in his paper on "Seasonal Fluctuations of Epidemic Diseases," in the "Epidemiological Society's Transactions," 1896–97. He points out, moreover, contrasting epidemic years with non-epidemic years, that in the former "the force of the disease is seen to fall on the second quarter, in non-epidemic years on the fourth quarter." In the same paper it is noted how charts exhibiting combined monthly or weekly deaths for a series of years are apt to give an erroneous impression. The double rise does not, of course, occur in each year ; the explosions occur biennially, or thereabouts, but are, as a rule, confined to the winter or spring months, and hence, when the figures for a series of years are considered, the maxima are found to present themselves in those months. Davidson attributes the change "from the winter to the

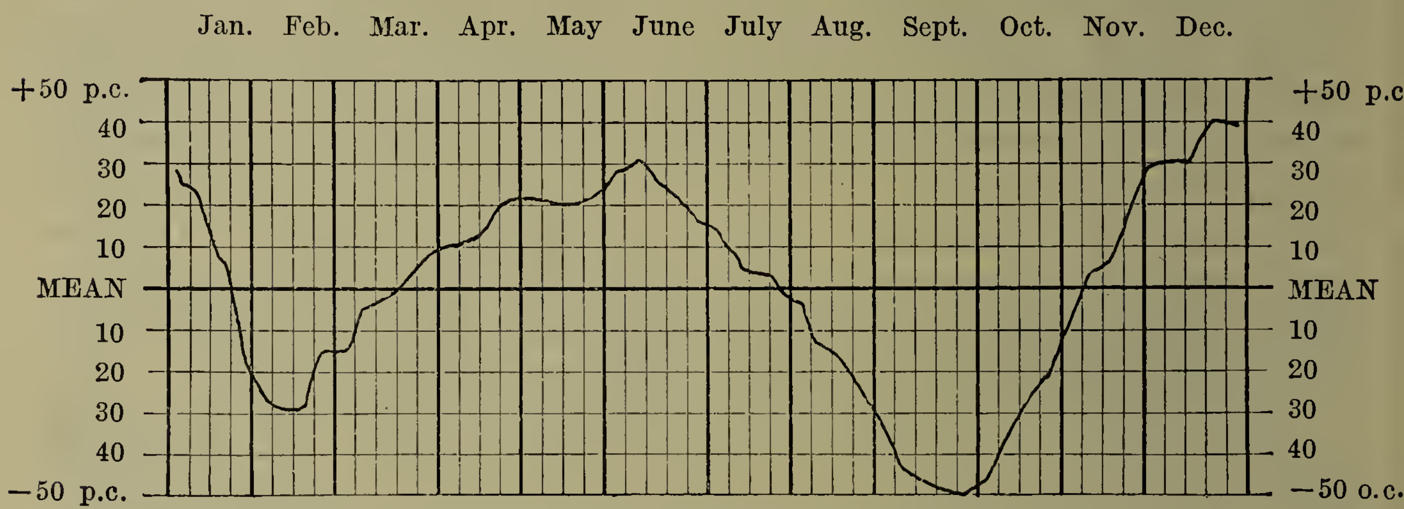

FIG. 79.—Measles in London (sixty years 1861–1900).
The mean line represents an average weekly number of thirty-six deaths.
(*After Shirley Murphy.*)

spring type" to increased prevalence and fatality of the disease. It may be noted, however, that in London, with increasing aggregation of susceptible units, the conditions may be presumed to have tended of late years towards favouring explosions of measles at somewhat shorter intervals—say to the establishment of an eighteen months' in place of a biennial interval between recurring epidemics,—and this factor in itself may have affected the seasonal curve.

There has been much speculation as to the conditions which determine the occurrence of the explosions at more or less fixed times of the year. Hirsch rejects the explanation that change in habit of life (crowding in close rooms, for example, in colder seasons) explains this, as he says a like dependence upon season obtains as markedly in the tropics as in high latitudes. It has been suggested that climatic conditions operate by establishing a *locus minoris resistentiæ* in the body, thus increasing the liability to contract infection at particular seasons. Davidson concludes that the behaviour of measles and small-pox resembles that of respiratory diseases, and he cites in confirmation of his views the average monthly admissions of pneumonia in the General Hospital in Vienna. He states that "increased vulnerability of the air-passages determines to a large extent the seasonal prevalence of bronchitis, pneumonia, and sore throat," and he argues that "as the infection of measles and small-pox takes place through the air-passages, the increased vulnerability which determines the greater prevalence of respiratory diseases in winter and spring furnishes an adequate explanation of the epidemic spread of the former class of maladies at these seasons."

Spear, in reporting on the Hanley outbreak of 1888–89, noted that there was no evidence to show that a close connection existed between fatality and unfavourable weather, or other recorded meteorological conditions. Whitelegge thinks there is, as a rule, no increase of severity accompanying the seasonal exacerbations of measles prevalence. Davidson refers to two types of seasonal evolution in measles : in London, the Lancashire towns, and elsewhere the winter maximum is notably developed ; the Scotch towns, on the other hand, show only a slight winter rise, but in them the June maximum is found to be particularly marked. This last-mentioned type occurs, too, in Paris, Berlin, Vienna, and in many American cities. The winter rise, indeed, tends to disappear altogether in southern regions, where the temperature in the winter months is high.

Race, *per se*, seems to have but little influence in determining liability to attack by, or fatality from, measles. Hirsch says, however, that when the disease occurs in warm climates, diarrhœa is apt to prove a serious complication.

Influence of Age—In this country the maximum death-rate, per million living, is exhibited at the age 1–2 years. The vast majority of deaths, some 98 per cent., occur in children under 10, and some 90 per cent. are those of infants under 5 years of age. The age 0–1 contributes, as a rule, about 21 per cent., the age 1–2 about 38 per cent. of the total deaths. The very young children constitute a larger percentage of those attacked in the great towns than is the case in sparsely populated areas. Age is a most important element in prognosis ; the lesser mortality at the higher ages is the reason of our efforts to stave off the disease till as late as possible in a child's life.

In 3,181 cases treated in the Glasgow Fever Hospital during 1897–99, a case-mortality at all ages of 9·68 was observed. At 0–1 the fatality was 23·4 per cent. ; at 1–2, 32·6 per cent. ; at 2–3, 17·6 per cent. ; at 3–4, 9·8 per cent. ; and at 4–5, 3·7 per cent. From 5–10 the fatality was 3·2 per cent. ; and from 10–15, 3·5 per cent. It is clear, therefore, that the proportion of children from 0–2 attacked in a particular epidemic may be expected to materially influence the general case-mortality observed.

Ninety-five per cent. of the deaths from measles occur from pneumonia due to streptococcal or pneumococcal invasion.

The heavy mortality from measles of American troops in 1918 attracted attention ; various measures were adopted. In some hospitals it was possible to isolate each patient with measles in a separate room or cubicle ; in other hospitals examinations of the throats for hæmolytic streptococci were made, and all such patients isolated ; both they and the nurses attending them wore gauze masks.

Measles lowers the resistance to other infections ; there is a marked leucopenia, the tuberculin reaction is in abeyance during an attack, and for some months afterwards. This is in accordance with the not infrequent onset of tuberculosis after an attack of measles.

The disease is very infectious ; when introduced into a community all persons who are not protected by a previous attack are affected without regard to age.

The susceptibility of adults to attack was strikingly shown during the War by the incidence of first attacks of measles in soldiers recruited from isolated districts.

Cause, Dissemination, and Prevention—The measles organism has not yet been definitely isolated. Hektoen has shown that the virus of measles is contained in the blood ; he has succeeded in transmitting the disease from man to man. The virus passes through a Berkefeld filter.

The period of incubation usually varies between eight and twelve days ; extremes of five and eighteen days have been held to occur. The disease spreads from person to person, the medium of infection being presumably, as a rule, the breath, and droplet infection on coughing or sneezing ; thus the infection is inhaled. Franz Mayr as long ago as 1852 showed by experiments on the human subject that the buccal and nasal secretions are infectious; this has been confirmed by experiments on monkeys which can also, it is alleged, be caused to contract the disease.

The infectivity is greatest in the early catarrhal stages before the rash develops and continues throughout the eruptive period and to a less extent during convalescence, probably terminating at the end of two weeks from the date of appearance of the rash. The virus is probably conveyed at times in the clothing of a third person for short distance; this accounts for some of the instances of cross-infection in hospital. Armstrong from his experience of the spread of measles in a school chapel, considered that by coughing and sneezing the virus could be propelled as far as nine feet. The possibility of transmission by air in hospital wards to further distances cannot be absolutely excluded.

No carriers have been found; epidemiological observations show that the virus of measles is frail and dies as quickly in the convalescent as in the environment.

Measles has not been found to be spread by water, milk, or food, and the disease is not known to affect any of the lower animals.

By an Order of the L.G.B. notification was required of the first case of measles in a household attended by a medical practitioner, and of each case in a household by the parents of the patient; this form of notification was abandoned on the ground that the experience was that the information had already been obtained by health visitors and from the schools. The Ministry, however, will allow of compulsory notification of *all* cases provided adequate use is made of the information obtained, *e.g.*, cases are visited by health visitors and home nursing or hospital accommodation is provided for suitable patients.

School closure is far more valuable for rural than urban schools; in rural schools a larger proportion of the children have not had measles, and the children, who often live far apart, do not mix together when not at school.

If measles is introduced into a school or class on a particular day a certain number will be affected about twelve days later; if these affected children be allowed to remain at school, at the end of another twelve days almost all the children who have not had measles will catch the disease. For school or class closure to be of any use the first batch of cases must be prevented from attending school during the stage before the rash appears. The school or class should therefore be closed on the ninth day after the sickening of the first child for a short period of five days. The parents should be asked to keep their children at home if the slightest sign of a cold develops during the next three weeks, and to let the head-teacher know.

Advantage may be taken of outbreaks during the holidays to prolong the vacation; the superintendents of Sunday schools should be approached with a view to simultaneous closure.

In the presence of an epidemic of measles (and whooping-cough), a procedure often adopted is to exclude all children under five years of age.

In boarding-schools advantage has been taken of Meunier's sign to isolate infected children during the incubation period. Meunier pointed out that from the fourth or fifth day after infection, a progressive loss of weight occurs which usually lasts until the first symptom of onset. In hospitals, etc., the presence of Koplik's spots, small bright red areas of irregular outline with a bluish white speck in the centre, found on the gum at the bases of the lower molars and on the inside of the middle of the cheek, within 24 hours of the onset of the attack, and the taking of the body temperature in the evening, enable children with measles to be separated from healthy children at an early stage of the disease.

Even if removal to hospital has very little influence in checking the spread of infection, it is of the greatest value in saving the lives of children from poverty-stricken homes. The value of home nursing by district nurses of children with measles is considerable. Thursfield's investigations in 1913 showed that the most frequent causes of death in measles were broncho-pneumonia and other complications caused by streptococcal (and in lesser degree pneumococcal) infection, probably derived from a septic condition of the mouth, fauces, or nasopharynx.

Immunisation of contacts with serum derived from patients or adults who have suffered from measles during infancy has been carried out in Germany in the presence of a severe form of measles or in weakly children; the claim made is that the disease is postponed to a later age.

Owing to the frailty of the virus, *disinfection* of the school or home after measles is unnecessary; domestic cleansing is adequate.

Mumps—This disease is said to have been known to the ancients and to have been described by Hippocrates. At the present time it appears to occur in all parts of the inhabited globe. Climate seems to have little influence upon it. In this country it is more prevalent, as a rule, in the spring and autumn, and it most frequently attacks children and young adults, but the majority of the deaths are those of very young children. The fatality is insignificant, only some eighty deaths annually being registered, throughout the whole of England and Wales, as due to the disease; of these 68 per cent. occur in persons aged 0 to 5 years. The organism which causes the disease has not been isolated; infection is spread, as a rule, from person to person, and the breath is presumed to be the medium of its conveyance. The period of incubation is a particularly long one, usually from a fortnight to three weeks. The occurrence of second and even third attacks has been recorded, but it is generally assumed that one attack affords protection against subsequent invasion.

The patient should be isolated for three weeks from the onset of the disease.

On account of the long incubation period and the absence of danger to life, exclusion of contacts from school is not usually recommended, as otherwise too great an interference with the school work is caused.

Plague—It has been observed that certain circumstances recorded concerning the "very great destruction," described in the fifth and sixth chapters of the First Book of Samuel, are very suggestive of bubonic plague. The "emerods," of which mention is made, may well have been buboes, and, in the light of recent experience, the reference to the "mice" that "marred the land" is especially noteworthy. Hirsch refers to an outbreak in Libya, Egypt, and Syria, some two centuries before the Christian era. The great epidemic, which spread from Egypt over Europe in the latter part of the sixth century A.D., and which is known as the "Plague of Justinian," and the famous "Black Death" of the fourteenth century, were almost certainly outbreaks of plague; from the sixth to the seventeenth centuries the disease appears to have been repeatedly present in Europe.

The last great outbreak in this country was the Great Plague, which raged in London in 1665, destroying nearly 100,000 persons. The disease did not leave England altogether until 1679, and outbreaks still occurred in parts of the Continent, and especially in south-east Europe, throughout the eighteenth century. In 1841 plague was still present in Constantinople, but this prevalence came to be regarded after a time as the final European visitation. Between 1860 and 1880 evidence of renewed activity of plague was forthcoming from countries bordering on the Levant; in 1878–9 cases occurred in Astrakhan.

In certain parts of the world plague has apparently been almost constantly present in modern times. Bruce Low speaks of Assyr in Arabia, portions of Persia and Mesopotamia, Southern China, especially the province of Yunnan, and possibly parts of Central Africa as endemic centres of the disease. From 1879 onwards, for some years, the outbreaks of plague which were heard of were confined to Arabs, Bedouins, and nomadic tribes. In February, 1894, however, a severe visitation of the disease was manifested in Canton, and Hongkong was attacked in the following May. In both these instances the occurrence of plague cases was preceded by mortality among rats. Towards the end of 1896 plague appeared in Bombay, and it later spread to other parts of India, Calcutta being definitely ascertained to be attacked in the spring of 1898. Since 1896 cases of plague have been introduced at various seaports in this country, but the disease has not spread. In 1898 three fatal cases occurred in Vienna, due to infection from cultures of the plague bacillus, originally derived eighteen months previously from India. In 1899 the disease manifested a tendency to spread more widely; cases appeared for the first time, so far as is known, in America, notably in Brazil, Paraguay, and the Argentine Republic; moreover, an outbreak occurred at Oporto. Early in 1900, Sydney, in Australia, was attacked, and in the autumn cases occurred in Glasgow; in 1901 the malady obtained a footing in Capetown and other parts of South Africa.

In 1910 four fatal cases believed to be cases of pneumonic plague occurred in East Suffolk. In 1910–11 an outbreak of pneumonic plague in Manchuria in which the marmot was held to be the carrier of infection was reported on by Farrar.

Wu-Lien-Teh in 1917 found that Mongolian marmots suffered at times from pneumonic plague and that they could transfer this form of the infection to other animals. He also found that he could infect marmots with plague by feeding them on the carcasses of animals that had died of the disease.

Between 1896 and 1917 upwards of ten million deaths occurred in India. Of late years the mortality has declined, and the number of deaths in 1921 was among the lowest on record since 1896.

The Plague Bacillus—The micro-organism of plague was discovered by Kitasato and Yersin in 1894; it is usually found in pure culture in buboes, and can be demonstrated as a minute short bacillus, showing, as a rule, marked "bipolar staining." Its cultures on agar are fairly characteristic, and it is pathogenic to mice, rats, guinea-pigs, and rabbits. Guinea-pigs quickly develop considerable œdema at the site of inoculation, with consecutive glandular enlargement; they die in from two to five days, and plague bacilli are abundantly present in their organs and blood. The *Bacillus pestis* grows well at temperatures between 15° and 40° C., best in presence of oxygen, but also under anaerobic conditions. It does not, so far as is known, produce spores. The formation of stalactite-like filaments, in broth cultures, was described by Haffkine; it is not, however, quite finally conclusive in determining the diagnosis of plague. To confirm clinical diagnosis the fluid from buboes or the sputum of pneumonia cases should be examined microscopically for the presence of *B. pestis* in whose identification definite bi-polar staining is of the highest importance. Confirmatory evidence must be obtained by the inoculation of mice or guinea-pigs—a positive diagnosis can only be made after microscopical and cultural tests of the matter derived from these animals.

The disappearance of plague with advancing civilisation in Europe, and the ability shown by the disease in recent years to attack the native quarters of Eastern cities, while Europeans enjoy comparative immunity, seem to indicate that there is some circumstance connected with life under conditions of modern civilisation which is inimical to plague. There has been much speculation as to this matter. The presence of dirt and overcrowding does not afford sufficient explanation in itself: various social customs—such, for example, as questions of clothing (going barefoot and the like), and methods of disposal of the dead (whether by burial at some depth from the surface, or by surface burial or other methods)—have been instanced as possible explanations; questions of altered relationship of communities to lower animals have also been mooted.

Of late years the fact that rats [1] die in large numbers from plague has been brought into prominence; the mortality in these animals has in some instances been found to precede outbreaks of the disease in man. The distribution of the buboes in plague, the deep femoral glands being particularly frequently affected, suggested that inoculation was the principal mode of infection in man; in some instances scratches or abrasions which would account for the phenomena observed have been discovered, usually on the feet or toes; the theory was advanced that the inoculation is effected in most instances by fleas.

In the tropics a domesticated black rat is found living in close contact with man and harbouring in its coat a flea—Xenopsylla cheopis. Simond found reason for concluding that infection could not be conveyed by dead rats after lapse of some hours from death; the infection, as he said, "evaporated": this he ascribed to the fact that the fleas leave the body of the rat when it becomes cold. Moreover, Simond found in certain instances papules or vesicles—"phlyctenules," as he called them—on the area corresponding to the bubo, and particularly on parts such as the dorsum of the foot where the skin is thin. Further, he detected plague bacilli in the phlyctenules, and in fleas from plague rats. It is now generally agreed that the evidence adduced by Simond of the spread of plague from rat to rat is conclusive, also that plague epizootics are spread by the brown sewer rat Mus norvegicus vel decumanus and that the black house rat Mus rattus usually receives its infection from the sewer rat. The exact manner of conveyance of infection has been the subject of further study on behalf of the Advisory Committee on Plague.

It is thought that either the flea by defæcating deposits plague bacilli near the puncture wound made when it bites man and that the infected fæces are rubbed into the wound in scratching the site of the bite, or that the flea when biting may regurgitate bacilli from its œsophagus.

There are many species of rat fleas, but only a few are known to carry plague and in addition to bite man. Of these only two are of importance, Xenopsylla cheopis, already mentioned, which lives on the coat of the rat itself, and Ceratophyllus fasciatus, living for choice in nests often underground and found in scanty numbers only on the rat. Rat fleas can carry infection for six to thirteen weeks.

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[1] In California the ground squirrel is incriminated; in Manchuria, the true marmot or tarabagan, and in S. Africa several small mammals have been shown to carry plague.

That rat fleas can be transported without their hosts in merchandise of different sorts, especially in grain and clothing, was experimentally demonstrated by the Commission; the general medical opinion in India is that infection there is often conveyed by means of transport of grain.

In the recent outbreaks in this country the first case has usually been connected with a rag store, a grain warehouse or with docks. The other cases occur in rapid succession in the house in which the first cases is nursed. Most, sometimes all, of the members of the household are infected and then suddenly the outbreak stops. If there are similar outbreaks in neighbouring houses, a definite connection between the two can usually be traced, either a visit of friends or by the receipt of clothing.

W. A. Lethem considers that these facts among others points to the spread of the disease in this country by Pulex irritans, and explains how the disease spreads in the absence of plague rats in the infected houses. It has been proved that clothing from an infected house was able to infect guinea-pigs several days later: the guinea-pigs were found to harbour both rats and human fleas; Verjbitski found that plague bacilli were present in human fleas (and bed bugs) up till the eighth day. Although possibly it is only in severe septicæmic cases with a sufficiently large number of bacilli circulating in the blood that a flea can be readily infected by man, yet the reasoning is sufficiently cogent to warrant a careful disinfestation of the whole of the house and the clothing, bedding, etc., in which a case of plague has occurred in order to destroy all fleas and bugs present.

Animals fed upon plague cultures are attacked by the disease, and the possibility that man may also be infected by ingesta must not be lost sight of; moreover, plague bacilli have been demonstrated in the intestinal contents, and hence the excreta may presumably serve as a vehicle for spreading infection. Inhalation probably plays, in instances in which the pneumonic form of the disease is prevalent, an important part in connection with spread of plague.

Seasonal Influence—The influence of season on plague is marked, but the question as to the meteorological factor mainly concerned in producing the conditions which favour its prevalence is by no means clear. In Western Europe plague in the past appears to have been a disease of late summer or autumn. In Bombay two maxima and two minima have usually appeared in the seasonal curve. Moos ("Indian Plague Commission," vol. iii.) gave reasons for concluding that the "more favourable the conditions for the virus to rise from the ground into the air, the greater is the mortality from plague"; or, as Buchan, to whom Moos's results were submitted, puts it, the curve showing the difference between the temperature of the soil at a depth of five feet, and the temperature of the air over the soil, agrees with the mortality curve. This association, as Buchan observes, is the more noteworthy, having regard to the fact that the principal maximum occurs when the weather is coldest and dryest, and the secondary maximum when the weather is moistest and wettest and the temperature very high.

In Hongkong, the epidemic abates as soon as the air temperature reaches 84° F.

Further study of seasonal influence has been made by the Advisory Committee on plague ; an account of this is given in their reports.

Age and sex seem to have little influence in determining attack by plague. The incubation period is, generally, from two to eight days. The fatality varies greatly, it is said, in different epidemics ; as a rule from 60 to 90 per cent. of those attacked die, but the mortality among Europeans has been, usually, less than this.

The ordinary type in man, that in which buboes develop, is known as bubonic plague. It is often held that pneumonia occurring secondarily in bubonic plague may cause the epidemic to become one of pneumonic plague which can be transmitted from man to man ; Norman White, however, considers that pneumonic plague only occurs in the presence of a symbiotic infection. In the Manchurian epidemic of 1911, which led to 50,000 deaths in six months, direct infection from patients was clearly shown to occur ; rats were not concerned in the spread.

Both the bubonic and the pneumonic types may become septicæmic or this type may exist from the start (pestis siderans). The nature of this type, if occurring apart from other forms of plague, can only be determined by examining blood smears and blood cultures ; it should, however, be remembered that there is almost always slight general enlargement of the lymphatic glands. In all forms of plague the bacilli may occur in the blood ; taking all cases together, probably in 50 per cent. the bacilli can be obtained by culture, but this proportion varies in different epidemics.

A mild kind of bubonic affection has been described as occurring in association with, or as preceding, outbreaks of true plague ; to this affection the term "pestis minor" or "pestis ambulans" has been applied. Only slight fever occurs with but little prostration and clouding of the consciousness accompanied by enlargement and tenderness of a group of lymphatic glands. A vesicle at the side of the flea bite can often be seen ; the fluid may teem with plague bacilli. The incubation period is from three to seven days.

The investigations of cases of pneumonic plague in East Suffolk constitute an instructive study. At Freston in 1910 four persons died from what was locally regarded as pneumonic plague under circumstances which pointed to the conclusion that the disease had spread from person to person by infection.

The first patient, a boy of 9, fell ill on the 12th of September and died on the 16th of September, the mother who nursed him was taken ill on September 21st and died on September 23rd. The father fell ill on the 28th and died on the 29th, and a friend who lived a short distance away and had nursed the mother also fell ill on the 26th and died on the 29th. The death of the boy was certified as Gastric Catarrh and Pneumonia, of the mother Septic Pneumonia, of the father and friend, Influenza and Pneumonia. The anomalous nature of the attacks attracted attention, dark blood-stained expectoration occurred in three of the cases, but did not resemble that seen in lobar pneumonia. The condition of the patients was more serious than the physical signs warranted, and the patients rapidly became worse without any clear evidence of corresponding lung involvement. The temperature was, generally speaking, out of proportion to the physical signs. Diarrhœa and vomiting were pronounced symptoms in three out of the four cases. Bacteriological examination of the brownish sputum of the mother showed the presence of a Gram negative bacillus which could not be cultured ; from the blood and lung juice of the father a Gram negative bacillus was grown in bouillon and on agar, which from the morphological and cultural appearances was identified as Bacillus pestis by a local bacteriologist, whose opinion was confirmed by well-known authorities. In the vicinity of the cottage rats had been seen in an obviously dying condition struggling across the road and only reaching the other side with the greatest difficulty. Subsequent investigations showed excessive mortality had been observed among rats in the neighbourhood ; the dead bodies not only of rats but of hares, of a cat and of a ferret were found and on examination were proved to have died of plague.

The administrative measures taken are detailed on p. 62 of the Annual Report of the L.G.B., 1910–11 ; Haffkine's plague prophylactic was made available. The view apparently taken was that the disease was probably introduced by grain-laden barges ; the occurrence of the plague-infected rats in circumscribed areas or pockets, as determined by the subsequent investigations of C. J. Martin and Rowland, suggested that transmission of infected fleas occurred ; the rats concerned were *Mus norvegicus vel decumanus*. The investigation brought into notice outbreaks which had occurred on the banks of the Orwell at Trimley in 1909–10. Eight cases had occurred, probably of bubonic and septicæmic plague, with four deaths, and at Shotley in 1906–7 eight cases of pneumonic plague with six deaths believed at the time to be due to influenza ; at both these places an undue mortality among rats and hares occurred at the time.

Prevention—As regards plague importation, in addition to the usual measures adopted with regard to diseases to which the Orders of the Local Government Board apply, the question of rats has to be borne in mind. A circular letter of the Local Government Board, issued in May, 1901, deals with this subject and prescribes certain precautions, which should be taken on the arrival of a vessel (whereon, during the voyage, plague, or suspected plague, has occurred), to prevent rats from the ship reaching the shore, and as regards destruction of rats, etc. The desirability of making inquiry concerning rat-sickness, and of instituting, if necessary, bacteriological examination of sick rats, particularly in the case of vessels from infected ports, is specially insisted upon in this letter ; it is further pointed out that rats when destroyed should not be handled, but should be at once cremated, nd that the vessels should be disinfected, and measures be taken to revent shore rats making their way to vessels lying in port.

It must be confessed that the attempts to secure deratisation of a hip are by no means always successful. According to Article 21 (6) f the 1903 Paris Convention, no longer in force, the rats on board a hip infected by plague must be destroyed either before or after dis-harge of cargo as quickly as possible and in any case, within a maxi-num period of 48 hours, in such a manner as to avoid damage to nerchandise and to the ship's plating and engines.[1] In Article 31 hips refusing to submit to measures prescribed by a Port Authority n virtue of the provisions of this Convention " shall be at liberty to ut out to sea " ; this still holds.

At times it is impossible to destroy the rats on board a ship with-ut discharging all the cargo, an operation which cannot always be ompleted within 48 hours.

Again, experience has shown the difficulty of complete deratisation ven of an empty vessel. Before and during the search of the cargo or rats a preparation such as kerosene emulsion should be liberally prayed to destroy fleas, the rat-catchers should wear tight overalls nd leggings to prevent them " catching " fleas. The same precau-ions should be taken by workmen unloading the cargo.

In Glasgow, in 1900, efforts were directed towards tracing all persons xposed to infection, and house-to-house visitation in the invaded rea was instituted ; all " contacts " were kept under observation in reception-house, such observation, in order to cover the incubation eriod of the disease, extending over fourteen days. They were llowed to go to work, but were medically examined each day, ometimes twice daily. Infected houses were evacuated, the " con-acts " being removed, and the dwellings were then carefully disin-ected. " Suspects," and actual cases of plague, were, of course, romptly removed to hospital. Rats were collected from various arts of the city and examined, but clear evidence that rats were ffected in Glasgow was not forthcoming in 1900. The majority of he cases occurred in persons who had attended one or other of two ' wakes," held over two persons presumed to have died of the disease.

In India, not merely infected houses, but entire villages and dis-ricts, have been evacuated, and the inhabitants segregated in camps, heir houses being then either disinfected, or in some instances burnt o the ground. Again, persons coming from infected localities into an area not yet attacked, have been detained for a week or more before being allowed to proceed, and segregation camps have, with this object, been established in connection with railway stations, etc.

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[1] Although the 1912 Convention has now been ratified, in English practice he Port Sanitary Authorities (Infectious Diseases) Regulations, 1920, largely overn the situation. But foreign ships would be within their rights were they o insist on the procedure laid down in the 1912 Convention. As rats cannot e destroyed on board without complete discharge of a ship the forty-eight hours imit in practice runs into anything up to three weeks.

Persons recovering from plague should not be allowed to leave hospital for at least a month from the commencement of their illness. Rats and mice should be destroyed and their bodies burned; and it has been urged that this should be done as a matter of precaution before plague actually appears in a district. Concealment of cases constitutes a great difficulty in the East, and in India and elsewhere compulsory inspection of dead bodies has been insisted upon. Precautions as regards cleanliness are, of course, most essential for persons brought in contact with plague; scratches and abrasions on exposed parts of the body should be protected against the possibility of inoculation; and Manson suggests that those engaged on plague duty should "wear boots and have the legs protected by trousers tied tightly round the ankles, or better, by putties." Haffkine's prophylactic and various protective sera have been employed in India and elsewhere with very considerable success in the prevention of the bubonic form, the incidence being reduced to one-fourth and the mortality to one-half; the immunity lasts for a considerable number of weeks, possibly for several months (Bannerman).

Large doses of anti-plague serum are of some curative value in bubonic plague if administered early. No such prophylactic or curative measures are of any avail in pneumonic or septicæmic plague.

Acute Primary Pneumonia—This disease was at one time regarded as due merely to exposure to cold, but of late years the opinion has steadily gained ground that acute lobar pneumonia, at any rate, is really a specific fever. It has been found, moreover, that epidemics of pneumonia sometimes occur, and that the disease then displays infectious property. Such outbreaks of pneumonia have apparently been observed on the Continent, and in America. Two epidemics were noted in India, in 1875 and 1882, and in this country an outbreak at Middlesbrough was investigated by Ballard in 1888, and another occurred at Scotter in Lincolnshire, in 1890.

The disease is occasionally contracted by hospital patients lying in beds adjacent to those occupied by pneumonia cases.

Climate has little or no influence upon pneumonia, but with respect to season, it may be noted that mortality is greatest in this country in the winter and spring months. Coloured races seem to be specially susceptible. Very fatal epidemics of pneumonia occur among tropical natives engaged on large engineering contracts. The broncho-pneumonic form is more usual, the infection tends to become generalised and to invade the meninges. With regard to sex, the mortality is greater in males than females, and this is particularly the case between the ages 35 and 65.

A history of a previous attack is often obtained. Acute primary pneumonia is now notifiable. Lobar or croupous pneumonia is the usual form occurring in adults; 95 per cent. of such cases are caused by the pneumoccus; lobular or broncho-pneumonia is the usual form found in children.

Seventy per cent. of the deaths from broncho-pneumonia occur during the first five years of life.

At least 4 distinct groups of pneumococci have been distinguished at the Rockefeller Institute, New York, chiefly by their agglutinating reactions. Eighty per cent. of all pneumoccal pneumonia cases are associated with pneumococci belonging to the groups Type I, II and III. Only 20 per cent. or less are associated with the presence of pneumococci of Group IV; to this type belong the great majority of the pneumococci found in the mouths of normal persons. Lister has found that in South Africa nearly one-third of the cases are associated with another type which apparently does not occur to any extent in New York. Rufus Cole states that pneumococci of Types I and II, which are responsible for 65 per cent. of the cases of pneumonia, are found *only* in association with the disease; in the few instances in which they had been discovered in the mouths of normal persons, careful investigations have shown that these persons were recently in very close contact with patients suffering from pneumonia due to the same type of pneumococci; in other words, they are "carriers." Pneumococci of these specific pathogenic types have also been found in the dust of rooms occupied by pneumonia patients. But neither in the dust nor in the expectoration of convalescent patients, nor in the saliva of healthy carriers have these organisms been found to persist for long; from carriers they disappear within a few weeks.

An immune serum which protects mice against infection with pneumococci of Type I has no effect against infection with pneumococci of Type II, and *vice versâ.* Unfortunately, only the serum treatment of pneumonia due to Type I pneumococcus, has been found to be successful; of 500 such cases treated at the hospital of the Rockefeller Institute the mortality was 10 per cent. as opposed to the usual mortality rate of 30 per cent. Early administration is of the greatest importance. The New York State Board of Health have made arrangements for bacteriological examination of sputum to determine the type of pneumoccus present, for supplying Type I serum, for advising as to its use, and for sending a trained man to administer it.

A very marked diminution in the incidence of pneumonia among the native labourers of the South African mines has followed the use of a pneumoccal vaccine.

Precautions should be taken to prevent spread of the disease by patients. A patient treated at home should have a separate room; in a hospital ward only a few cases of pneumonia should be treated in one ward, these beds being separated from the others by screens. The sputum and soiled handkerchiefs should be disinfected.

Malaria—This disease was known to the Greeks and Romans; Hippocrates discussed its relation to season. In the sixteenth, seventeenth, and eighteenth centuries it received some measure of attention, and it again figures in the works of medical writers. In the middle of the last century Virchow studied the pigment observed on post-mortem examination of malaria cases, and at about this time the suspicion appears to have been already entertained, by various observers, that the disease was due to invasion of the body by some lowly organism; it is interesting to note that the suggestion that the mosquito was concerned in producing malaria was definitely put forward as early as 1848. Klebs and Tommasi-Crudeli, in 1879, contended that a bacillus was the cause of the malady.

In 1880, Laveran drew attention to the presence of "crescents" in the blood of malaria patients, and he subsequently described the "amœboid form" of the organism and also some of the changes which the crescents undergo; he thus laid a foundation upon which subsequent study of the "malariæ plasmodium," as he called the parasite, has been based. Golgi materially added to this knowledge by distinguishing between the different forms of parasite in quartan ague with its cycle of forty-eight hours and benign tertian ague with a periodicity of seventy-two hours, and showing the relation, of stages of their growth in the blood, to the periodicity of the symptoms observed. In 1892 Koch and Pfeiffer suggested that in the case of the malarial parasite, as in that of the coccidia, there might be a double cycle of development, one cycle occurring in man, the other possibly in some suctorial insect.

The Mosquito Theory—In 1894 Manson, who had years previously worked out the relation of the mosquito to filariasis, suggested that this insect also played an important part in disseminating malaria. The need of explaining the conveyance of the parasite from man to man was obvious in malaria, as it had been in filariasis; the geographical distribution of *Filaria nocturna*, as Manson pointed out, corresponded with that of malaria, suggesting that the mosquito might serve for transmitting the parasite of malaria as well as that of filariasis; the association of the mosquito with swamps, and with high atmospheric temperatures, and its nocturnal habits, all tended to confirm the hypothesis; moreover, the crescents of malarial blood, when removed from the body, had been found to undergo development and to become possessed of flagella, and this acquirement of locomotive and penetrating faculty led Manson to conclude that here was the initial phase of the mosquito cycle of development.

Surgeon-Major Ross took up the study of the mosquito theory; working at first with the ordinary mosquito (Culex), he was merely able to show that the development of the "flagellated body" took place somewhat more readily in the stomach of the insect than under the ordinary circumstances in which the behaviour of the crescents, in a drop of blood taken from man, could be watched. On experimenting, however, with the genus Anopheles, in 1897, he was able to demonstrate the existence of pigmented cells in the stomach-wall of the mosquito, after it had been supplied with crescent-containing blood, and thus to detect a further stage in the mosquito cycle of development. Attention, moreover, became directed to the fact that forms of parasites, allied to the human malaria parasite, could be demonstrated in the blood of sparrows and other birds. Ross studied one of these organisms (Proteosoma), and showed that when he fed the mosquito (Culex, in this instance) with sparrow's blood containing the parasite, and then kept the insect alive for rather more than a week, it was possible to demonstrate the presence of the sporozoites of Proteosoma in the mosquito's veneno-salivary gland. If infected mosquitoes were made to bite healthy sparrows it was found, after five to eight days, that evidence that the sparrows had been infected was forthcoming on examination of their blood.

To test the mosquito theory, Sambon and Low in 1900 lived for three of the most malarial months of the year in one of the most malarial parts of the Roman Campagna in a mosquito-screened hut, and did not contract the disease. Mosquitoes fed on blood from a case of benign tertian malaria, were sent from Rome to London and allowed to feed on two volunteers, who subsequently went down with this form of the disease, the parasite being recovered from their blood.

Bass in 1911 cultivated the parasites of malaria from a patient's blood.

The Malaria Parasite—The animal parasites producing human malaria belong to the Hæmamœba type of the order Hæmosporidia of the class Sporozoa and of the phylum Protozoa. They comprise three species, *Plasmodium vivax*, the cause of benign tertian; *P. malariæ* of quartan, and *P. falciparum* of æstivo-autumnal or malignant tertian.

Other Hæmosporidia of the Hæmamœba type have been found in birds, monkeys, bats and squirrels, and possibly in reptiles.

In the two Englishmen deliberately infected with benign tertian in London by mosquito bites, the incubation period was fourteen and fifteen days respectively. When infection is produced by injection of malarial blood the incubation period is about thirteen days in quartan, about ten days in benign tertian, and about three days in æstivo-autumnal fever.

The asexual cycle of development of the malaria organism occurs, so far as is known, only in the human body; a remarkable feature is the relation of the phases of this development to the stage of the attack.

If the blood be examined immediately after a rigor, small amœboid organisms (amœbulæ) may be found in the blood corpuscles; these increase in size, develop pigment, and at length, shortly before the next paroxysm becomes due, occupy almost the entire volume of the blood corpuscles. At this stage, on examination of stained specimens, the nucleus, hitherto single, is found to have become broken up, and sporulation is found to be well advanced, the "rosette body" or "sporocyte" stage, as it is termed, being now reached. The breaking-up of the "rosette body" with freeing of the contained spores, corresponds in point of time with the onset of the ague paroxysm. The sporocyte of quartan ague is described as being of "daisy shape" and contains six to fourteen round spores; that of benign tertian ague is of "sunflower shape" and contains fifteen to twenty-six oval spores; that of malignant malaria is of irregular shape and contains seven to fifteen round and very small spores.

The reason why the parasites all mature and reach the sporulating stage at about the same time is not understood. The cycle of development is, under certain circumstances, moreover, shortened or lengthened; in the former case the fever is said to "anticipate," in the latter to "postpone." In malignant malaria it is noteworthy that, while in the earlier part of the cycle the parasites may abound in the peripheral circulation, just before the paroxysm they tend to disappear, but may then be found undergoing sporulation in the spleen and some other organs. The accumulation of parasites in internal organs is presumed to stand in close relation to development of pernicious symptoms. In order to explain the recurrence of attacks of ague, after a period of freedom from symptoms, and under circumstances in which fresh infection from without is out of the question, it is necessary to assume that the parasite can enter into a resting state, or assume a latent phase, but with regard to this nothing is precisely known.

In addition to the ordinary asexual cycle in the human body, it has been ascertained that a sexual cycle of development may be there initiated. Certain of the parasites, while within the red blood corpuscles, appear to develop into spheres, some of which possess flagella, while others do not. These two varieties are called gametocytes, and represent male and female elements. The crescent bodies, which only occur in malignant malarial infection, develop in the mosquito, or in fresh preparations, two sorts of spheres, flagellated and non-flagellated, corresponding to the gametocytes of the benign quartans and tertians. The study of these sexual forms has been much facilitated by adopting the staining process known as the Romanowsky method. Further stages in the history of the sexual cycle have been observed, in Halteridium, which result in the production of worm-like bodies, "travelling vermicules." These, it is said, subsequently develop, after piercing the stomach-wall of the mosquito, into what are termed "zygotes." Analogous phenomena are presumed to occur also in human malaria. In infected mosquitoes the further development of the zygotes, through a series of transformations (zygotomeres, blastophores, and, ultimately, mature zygotes which contain numerous sickle-shaped "sporozoites") has been traced. The whole process occupies some six to ten days; the sporozoites finally escape into the body cavity of the mosquito and are conveyed to the veneno-salivary glands; their existence, in large numbers, has been demonstrated more particularly in the middle lobe of the gland. When the mosquito bites, these sporozoites are injected into the tissues of the bitten animal.

Uncertainty exists as to the complete number of different species of the anopheline sub-family of mosquitoes in which the full development of the parasite can take place; eleven have been proved and one is suspected. A species which may be the chief transmitter in one country may in another be unimportant even though present. In this country Anopheles maculipennis is the only mosquito proved to be a transmitter, but A. bifurcatus and A. plumbeus are under suspicion. Culicine mosquitoes never transmit malaria.

Anopheles is distinguished by the fact that the palpi in both sexes are equal in length to the proboscis. The ova are minute black specks, and float on the surface of the pools, ditches, etc., in which they are laid. In Culex the ova are generally arranged in boat-shaped masses; but they are more irregularly disposed, though sometimes with indication of a star-shaped arrangement, in Anopheles. The larvæ hatch out after some twenty-four hours, those of Culex swim about actively; those of Anopheles are less active, and are, moreover, smaller and darker. Again, in Culex the larvæ hang head downwards, and at right angles to the surface, the breathing organ being situated in the tail; while in Anopheles the larvæ float flat on the surface, owing to the absence of a caudal breathing tube. The pupa stage supervenes after about a week, and some two or three days later the perfect insect escapes.

The female insect alone bites and generally speaking only towards evening or at night. The duration of its life extends for several weeks; in places where there is a cold season it is able to hibernate. Ross laid emphasis upon the resting attitude of Anopheles as distinguishing it from Culex; in the former the body being placed almost at right angles, while in the latter it is parallel to the surface on which the insect has alighted. The distinction does not hold good as regards all species, and a more reliable criterion is said to be, that whereas Culex has a hunchback appearance when at rest, Anopheles keeps its "proboscis, head, thorax, and abdomen in one straight line."

Koch demonstrated that the infections of lower animals resembling malaria had no part in the causation of human malaria and that the malarial parasite could only pass between man and certain mosquitoes.

Geographical Distribution—Hirsch states that malaria covers "a broad zone on both sides of the equator," attaining "a maximum of frequency in tropical and sub-tropical regions," but continuing "to be endemic for some distance into the temperate zone, with diminishing severity and frequency towards the higher latitudes." The disease prevails in tropical Africa and especially on the west coast; in Asia (India, Ceylon, China and the Malay Peninsula, and parts of the East Indies); in certain of the southern states of the Union in North America; in many localities in Central America; and in parts of South America. The islands of the West Indies are comparatively free from it; so is Australia, save as regards northern Queensland. In Europe malaria mainly occurs in the countries bordering on the Mediterranean.

The benign tertian form is by far the most common outside the tropics; for the most part in Europe malaria is benign, though in the Roman Campagna the malignant æstivo-autumnal or malignant tertian form occurs. Double infection may occur, in which case two paroxysms may develop within twenty-four hours; or, as is more usual, a double tertian or quotidian fever is produced, two sets of parasites sporulating on alternate days. The benign quartan form, though less frequently met with than the tertian, is not uncommon in temperate regions; the infection may be single, double, or it is said, even treble; if the last-named, a quotidian fever is produced; if the infection be double, there are two days of fever and one of freedom from fever; if the infection be single, the ordinary quartan type obtains.

During six years following 1917, 500 cases of indigenous origin were detected in England. All the infections were with the benign tertian parasite (*P. vivax*). The rule is for a few cases to arise in a number of widely separate places. Kent furnished more than any other area; the endemic type of malaria formerly so prevalent still persists in the islands of Sheppey and Grain.

The return to this country of many ex-Service men who had suffered with malaria has evidently not caused the spread of the disease, to any very marked extent; this has probably been due to the absence of conditions favourable to close and continuous association between the malaria carriers, the anophelines, and the susceptible persons in the locality. Stitt holds that an atmospheric temperature above 60° F. is necessary.

Pernicious manifestations of malaria arise almost exclusively in the course of malignant tertian infections. Relapses of malaria often occur some time after a person has left a malarious locality, the "latent phase" of the parasite is then said to become "active." The tendency to relapse apparently persists longer in the case of quartan than in that of malignant tertian.

Malarial cachexia with its physical and mental incapacity may be produced as the result of repeated attacks of any type of malaria.

Preventive Measures—Malaria is not usually developed in towns, as drainage, paving, etc., interfere with the breeding of the mosquito; moreover, the anophelines are more rural in their habits than other mosquitoes. Again, mosquitoes are low flying, so that sleeping in the upper storey of a house may serve as a safeguard against attack. Mosquitoes do not, as a rule, fly far from their breeding-places, which are usually small collections of water [1] or sluggish streams, especially where there is a luxuriant growth of weeds or grass. This fact explains the freedom from malaria, often enjoyed by persons on board ships, anchored at some little distance from the shore of intensely malarious localities. Koch showed that in New Guinea the blood of nearly all young native children contained malarial parasites, while that of adults did not. The comparative immunity of natives, therefore, appears to be an acquired immunity. Manson writes that until some method of producing artificial immunity is devised, prophylaxis must be directed to the suppression of mosquitoes, to the prevention of infection of mosquitoes, or to the prevention of infection by mosquitoes.

The prevalence of malaria has certainly been diminished by measures directed against the larvæ of mosquitoes. The drainage of swamps has been especially efficacious; the utilisation of the land for agricultural purposes by producing greater prosperity in the district, has enabled the local population to obtain better shelter and better food, two factors producing physical improvement and increasing the resistance. Pools, etc., suitable for the breeding of Anopheles, should, it is urged, be filled up; if this cannot be done, larvicidal material should be applied to the water. Mixtures of soft soap and crude petroleum are held to be better than crude petroleum alone, half a pint per 100 square feet should be used, and the process repeated fortnightly; creosol, 1 to 1,000,000, parts has also been advised, the notion being that, by forming a thin layer on the surface of the water, the access of air to the larvæ and pupæ would be prevented. Paris green, mixed with dust so as to form a scanty surface deposit, has been recommended for weedy pools where liquids do not spread; anopheline larvæ being surface feeders, ingest it, and are killed.

Crude carbolic acid, 1 oz. to 16 cubic feet of water, has also been recommended.

The use of fish, *e.g.*, Gasterosteus aculeatus (the five-spined stickleback), which consume the larvæ of mosquitoes, has been suggested.

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[1] Even roof gutters must be searched for larvæ of incriminated mosquitoes and dealt with, if necessary.

Measures against the adult mosquito include the clearing away of grass and brush from around houses, thus exposing the insects to the direct heat of the sun, in which they cannot live long. Inside the houses they can be destroyed by sulphur fumigation or Giemsa's spray.

Pending the carrying out of measures of one kind or the other, reliance must, in the main, of necessity be placed by the individual upon attempting to protect himself against being bitten by mosquitoes; any mosquitoes in houses should be swatted. Experiments carried out in the Roman Campagna show that by remaining in a mosquito-proof house from sunset to sunrise it is possible to continue to live in a malarious district and yet remain free from attack. In cases in which a mosquito-proof house is not available, a good deal may be done by using an efficient mosquito net at night, with protection by a veil for the face and coverings for the hands and ankles. According to Stitt the application of certain pine products, used also as mange cures, will keep away mosquitoes. Not only the haunts of the mosquito but also infected individuals and particularly the neighbourhood of native villages should be avoided.

Elevation of site of the dwelling is desirable, but in some places "hill fevers" occur, even at a considerable height above sea-level. The higher the site, however, the better as a general rule; houses themselves may be raised above the ground on arches or piles. Koch proposed to exterminate malaria by destroying at one and the same time all parasites in the blood of infected persons in a given community, by exhibition of quinine. Early treatment with this drug reduces the number of gametocytes in the peripheral circulation if it does not absolutely prevent their appearance. If such treatment were universally adopted, and all parasites were thus destroyed or driven from the peripheral circulation, mosquitoes could no more become infected, and malaria must, he argues, cease.

Prophylactic doses of quinine, *e.g.*, 9 grains daily, have been given to new-comers in order to prevent their contracting malaria. In the region where it is applied quinine prophylaxis alone does not prevent infection; the parasites become immune to quinine and later when the patients leave the station for cooler climates and the prophylaxis is discontinued, malaria breaks out, and they do not respond satisfactorily to quinine treatment even if administered intramuscularly. However, on military, sporting, and exploring expeditions in the tropics or sub-tropics quinine prophylaxis and mosquito nets [1] are the only means available.

The extirpation of the parasites of malarial carriers by the use of quinine is of great practical value.

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[1] Mosquito nets prevent yellow fever, dengue and filariasis as well as malaria.

Blackwater Fever—A form of fever known variously as "Blackwater ever," bilious remittent fever, hæmoglobinuric fever, etc., affecting almost ntirely the non-indigenous population, prevails throughout tropical Africa, in he southern states of the North American Union, and in parts of Central America, nd has been observed in India. In Europe it has been described in the Balkans, reece, Sicily, Sardinia, and Central Italy. The mortality is high, 20 per cent. nd upwards, and relapses are common. The characteristic symptoms are æmoglobinuria with its accompanying rapidly developing anæmia, preceded s a rule by fever, nausea, bilious vomiting, epigastric distress and intense jaundice. This group of symptoms is generally regarded as connected with epeated attacks of malaria, almost solely of the malignant tertian type. J. G. homson examined 23 cases in Southern Rhodesia "prior to the onset of blackwater symptoms, and in every case was able to demonstrate the presence of malaria parasites of the malignant tertian type, although these disappeared with r shortly following the commencement of hæmoglobinuria. He recognises a ondition named the "pre-blackwater fever type"; in it a small dose of quinine will actually precipitate hæmoglobinuria, and it develops in patients suffering from chronic malaria who take quinine irregularly and inefficiently."[1]

Although quinine administration, especially if the patient has got wet, and has been chilled by a sea breeze, is the most common immediate cause, blackwater fever can develop without the previous administration of quinine.

Certainly a small percentage of cases diagnosed as blackwater fever during life, do not show evidence of malarial infection on post-mortem examination, and a few instances of blackwater fever have been recorded in which the patient has never had malarial fever.

Among those undergoing efficient quinine prophylaxis and using mosquito protection in the Panama Canal Zone, the disease has almost disappeared; others neglecting these precautions have suffered.

Poliomyelitis—Although the disease chiefly attacks children during the first three years of life, older subjects are also affected; in some epidemics adults are markedly attacked. Well known in its sporadic form for many years, since the epidemic of poliomyelitis in Sweden in 1905–6 the disease has been carefully studied and has been found to occur in epidemic form in various parts of the world, notably in Northern Europe and also in the United States of America, where outbreaks of varying intensity have been reported since 1907, when an outbreak took place in New York in which over 2,000 persons were attacked.

In 1909 Landsteiner and Popper in Vienna and Flexner in New York produced the disease in monkeys. Subsequently it was found that the virus can pass through a Berkefeld filter, and Flexner and Noguchi have succeeded in cultivating from the brain especially and from the infective filtrate, minute "globoid" bodies which have since been microscopically demonstrated in the brains from human cases and from monkeys experimentally inoculated.

An outbreak of poliomyelitis in epidemic form in Devon and Cornwall in 1911[2] led to the disease being made notifiable in September, 1912. In 1912–17 the numbers of cases notified were 839, 745, 503, 500, 689 and 357 respectively.

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[1] "B. M. J.," Dec. 8th, 1923, p. 1104.

[2] See Reports to the L.G.B., New Series, No. 61.

The season of maximum prevalence in this country is in the autumn. The case fatality is about 14 per cent.; unfortunately half the survivors remain permanently crippled. No instance is recorded of a second attack of poliomyelitis. That the disease is one which can be accompanied by very severe mortality was shown in New York City in 1916, when some 8,900 persons were attacked, of whom about 2,400 died.

Reece's inquiry in Devon and Cornwall in 1911 is now a classic. He visited Holsworthy in Devon to ascertain whether a few cases occurring there were cerebro-spinal fever as was locally believed and to take any preventive steps necessary in conjunction with the Sanitary Authorities concerned. Not only did he soon satisfy himself that the symptoms of the cases in question were those of poliomyelitis, but by making systematic inquiries in Devon and Cornwall, traced 154 cases, of which 34 were fatal. Material from fatal cases was examined by M. H. Gordon, who found that lesions typical of poliomyelitis were present in the spinal cords; material forwarded to Levaditi in Paris was there found to produce typical acute poliomyelitis on inoculation into monkeys.

The characteristic features of acute poliomyelitis in the early stage are sudden onset with fever, vomiting, diarrhœa, and constipation, occasionally sore throat, headache, and feeling of weakness, drowsiness and irritability in children, or restlessness and anxiety in older persons, pains in the neck, back and muscles, muscular twitchings and increased or abolished tendon reflexes. The clinical picture prior to the onset of paralysis may be that of an indefinite general infection or toxæmia, gastro-enteritis (the disease has been mistaken for food poisoning), tonsillitis, multiple neuritis, meningitis or encephalitis.

In epidemics, cases of the disease are found showing much diversity in the degree and extent of paralysis. In the same group may be found cases resulting in extensive and permanent paralysis, cases with paralysis of slight extent, cases of transient paralysis recovering completely within a few weeks or even a few days and others without any definite paralysis but with muscular weakness of short duration. The diagnosis of poliomyelitis in the slighter cases is suggested by their close association with typical cases; the symptoms of onset are identical, however, with those of undoubted cases.

The meningeal form of poliomyelitis originally described by Wickman, frequently met with in some epidemics, so closely resembles cerebro-spinal fever that it is only by bacteriological examination of the cerebro-spinal fluid that the two diseases can be differentiated.[1]

The cerebral type of poliomyelitis—the acute polio-encephalitis of Strumpell—bears some resemblance to cerebro-spinal fever. Cases exhibiting marked cerebral symptoms are often diagnosed as "acute polio-encephalitis," and to differentiate them from encephalitis lethargica, the separate notification of cases of acute polio-encephalitis was required.

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[1] "Cerebro-spinal Fever," Horder, p. 119.

The occurrence of multiple cases in houses, some in series, is a common feature in epidemics and suggests that person to person infection is operative, sometimes with much intensity. Wickman's observations in Sweden and Netter's in France have inculpated schools; school attendance was probably responsible for the subsequent but not the initial spread of the disease among the scholars at the Stoke Rivers school in 1911, where 16 out of the 26 scholars were attacked.

As the worst epidemics of poliomyelitis occur in summer, the possibility of transmission by insects has been suggested. On experimental evidence Levaditi exculpates bugs, lice, flies and the stable flies.[1]

Flexner and Clark have shown, however, that house flies contaminated with the virus of poliomyelitis harbour the virus in a living and infectious state for at least 48 hours.

The occurrence of poliomyelitis in the hot, dry, dusty season gave rise to the surmise that dust might be a factor in the spread of the disease. Not only have Landsteiner and Levaditi shown that the virus resists desiccation, but Neustaedter and Theo have produced typical poliomyelitis by injecting into a monkey 50 grams of dust obtained from the room of a patient. The Committee investigating an epidemic in New York, stated that it was impossible to learn of any infection of the lower animals which might have any relation to poliomyelitis.

Secretions from the naso-pharynx contain the virus. In monkeys recovered from the disease the nasal mucosa remains infectious for many months.

Urotropin has mitigated the effects of the injection of the virus of poliomyelitis in a proportion of monkeys in which this drug was already present in the cerebro-spinal fluid, and which were given the drug by the mouth subsequently. The serum from recently recovered human cases arrests paralysis when injected into patients suffering from poliomyelitis, especially during the first forty-eight hours.

Evidence of the spread of the disease by a healthy carrier is forthcoming in a number of epidemics recorded. A typical instance recorded by Reece [2] follows:—While a boy aged 6 years was suffering from an undoubted attack of poliomyelitis, on Aug. 2nd, his father, who had been well and remained well, delivered a horse to an isolated farm-house, and at tea sat between two boys aged 5½ and 2½ years. On August 8th both these children went down with poliomyelitis, on August 11th their mother began to suffer from an attack which proved abortive, next day an abortive attack occurred in an infant aged 8 months.

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[1] "Ectodermoses neurotropes," p. 80.

[2] See p. 84, "Annual Report, L.G.B.," 1911–12.

Milk has been held responsible for the spread in exceptional instances.

Wickman describes a small epidemic in which a son of a dairyman fell ill on October 6th with poliomyelitis; of nine cases which subsequently became ill, four, belonging to those families who obtained their milk from this dairyman, fell ill on October 20th; on the same day the ninth case, another son of the dairyman, became ill, and exhibited paralysis of the legs. This may, however, be a coincidence. Levaditi and Kling when in Sweden in 1912 were unable to prove that either milk or water played a part in the spread of the disease.[1]

In Sweden, infection of his sketches by an artist was held to be responsible for the disease in a woman who handled them.

Notified cases should be visited at intervals to ensure that suitable treatment is secured promptly and continuously so as to minimise any crippling.

Rabies (*Hydrophobia*) is a disease occasionally produced in human beings who have been bitten by a dog or other animal affected with "rabies." Wolves, jackals, foxes and hyænas are frequently the subjects of rabies; cats and horses are very rarely attacked, all mammalian animals are susceptible, and some birds.

The infective agent is present in the saliva; to pass on the disease it must be inoculated into the tissues, a breach of surface of the skin or mucosa must be present, but these may be so minute as to escape the naked eye, and the disease even may be contracted as the result of being licked by an animal subsequently found to have the disease or by merely washing out the mouth of a rabid horse.

In dogs the incubation period is from three to six weeks. The symptoms are change in the manner and habits of the dog, who is at times unusually affectionate, at others snaps at its human friends; hiding in dark places to avoid the light, gnawing and eating indigestible substances; a peculiar howl is substituted for the ordinary bark; difficulty in swallowing, but no dread of water. In the furious form these symptoms are followed by fits of excitement; the dog tries to attack any animals or persons approaching it. The dog usually runs away from its home, snapping at anybody and anything that comes in the way, and continues its march until paralysis sets in. The lower jaw falls, the hind legs cannot support the body, the animal drops helpless. The average length of the disease is 4 to 5 days, it rarely exceeds 10 days. In the less frequent form, dumb rabies, the preliminary stage of excitement is brief or absent.

Any dog showing these symptoms should be kept chained up until seen by a veterinary surgeon.

A wound inflicted by such an animal should be treated with

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[1] "Ectodermoses neurotropes," p. 78.

ndiluted disinfectant, or thoroughly irrigated with water, and the
atient sent to the nearest centre[1] for anti-rabic treatment.

The animal should be observed for ten days for the characteristic
ymptoms. After death the brain and spinal cord of the dog should
e sent packed in ice to the Board of Agriculture and Fisheries in
rder that the diagnosis may be verified.

The presence of Negri's bodies are a positive indication of rabies,
ut their absence does not mean that the disease is not rabies. The
urther examination consists of the insertion of a small quantity of
he medulla or pons of the suspected animal under the dura mater
f a rabbit or guinea-pig; in a positive case symptoms occur within
month.

In man the incubation period is generally about six weeks; it
ay be as short as eleven days, and on the other hand may extend
o four years. There is sometimes pain at the site of the scar caused
y the bite and along the nerves of the limb bitten and accompanying
nlargement of the neighbouring lymphatic glands. This is followed
y a stage of nervous irritability, during which all the reflexes are
uch increased. Spasms of the muscles of the throat prevent swallow-
g, attacks of dyspnœa occur as the result of spasm of the respiratory
uscles, delirium sets in. A period in which all the reflexes are dimin-
shed succeeds, weakness and paralysis are observed, convulsions
ccur, death is ushered in by coma. The illness usually lasts from
hree to four days and is invariably fatal. A paralytic type has been
bserved in which the first symptom is paralysis of the part which
as bitten, later widespread and progressive paralysis occurs.

Rabies occurs in almost all parts of the world. In England some
ounties have suffered more than others; London has yielded a con-
iderable percentage of the total number of cases. From 1838 for
any years, the deaths from rabies in the metropolis averaged about
hree or four annually. In some years no death has been recorded;
1885 there were twenty-seven. Cases occur rather more commonly
July, August, and September than at other times of the year.

In Pasteur's treatment by preventive inoculation, use is made of
he experimental findings that the spinal cord of a rabbit which
as been rendered rabid, contains the virus in an intensified form,
ut by exposing the cord to dry air its virulence becomes weakened,
nd after some days it may be employed, as Pasteur showed by
xperiments performed in dogs, for the purposes of preventive inocula-
on. As a rule, injections of material derived from a cord dried for
urteen days are first made, then material from cords which have
een dried a less and less number of days is employed, the treatment
sting altogether about a fortnight. "Intensive treatment" is
dopted in exceptionally severe cases.

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[1] See "Memo. of Ministry of Health," October, 1924.

The case-mortality of patients treated at the Pasteur Institute, i Paris, is about ·5 per cent., excluding deaths occurring during treat ment, or within fifteen days of the last inoculation, the time require to induce active immunity. The natural case-mortality amon persons bitten by rabid animals is very difficult of ascertainment but probably about 10–15 per cent. develop hydrophobia, and as th disease is almost necessarily fatal, obviously a far higher percentag of deaths than that recorded at the Pasteur Institute would occur i the absence of treatment. Rabies can be completely stamped ou by rigorous enforcement of muzzling. This has been proved i Sweden and in Berlin; in England also excellent results have bee obtained, but there has been a tendency to abandon the regulation as soon as a marked impression on the prevalence of the diseas has been produced.

Rat-bite Fever (Sodoku) occurs especially in Japan, but has been reporte in China, Australia, several European countries and America: it is a fever o the relapsing type, caused by infection of man with Leptospira morsus-muris by the bite of a rat infected with this spirochæte. After the healing of the bit inflammation occurs in the scar with lymphangitis and swelling of the tributar lymphatic glands.

The onset is sudden with rigors and fever which lasts several days; nephriti may appear; after an apyrexial period, relapse occurs. The disease is characterised by relapses which may occur for years. The mortality in man i about 10 per cent.

Relapsing Fever—The early history of this disease is enveloped in obscurity. Outbreaks occurred in Dublin from 1739 onwards; from 1799 account of the malady are forthcoming from Scotland; again in the great fever years, 1847–8, it was recognised in some of the English towns. In 1868–73 i again appeared in England and Scotland, and Hirsch states that in Londo the earliest cases occurred "chiefly in a quarter inhabited by Irish and by poo Jewish families from Poland." Relapsing fever has been observed in othe parts of Europe, notably in Turkey, Russia and in Germany. It was a diseas of importance during the Balkan War of 1912–13.

The relapsing fevers of (i) East and West Africa (tick fever), (ii) Northern Africa and Egypt, (iii) India, (iv) America, and (v) Persia are now each held to be caused by different spironemata.

The deaths recorded as due to the disease in this country, since 1869, have diminished in striking correspondence with the decline manifested by typhus deaths.

Relapsing fever sometimes prevails concurrently with typhus epidemics, the explanation probably being that both in Europe at least are spread through the agency of the body louse.

Relapsing fevers are caused by flagellate protozoa, spironemata (spirochætes). In 1873 Obermeier found these organisms (then termed spirilla), during the febrile stage, in the blood of persons attacked by relapsing fever. These organisms are very long, thin, actively motile, and show no appearance of being made up of shorter elements. They disappear from the peripheral circulation before the febrile stage comes to an end. Vandyke Carter, in 1881, produced typical relapsing fever in the ape, by injection of blood containing spirilla, and the disease has also been developed in man by inoculation. Spironema duttoni, responsible for East and West African relapsing fever, has been cultivated by Noguchi.

Several forms of relapsing fever, including the European forms, are transitted by the head and body louse, the infective agent is contained in the cœloic fluid, and it is only by crushing the louse that the louse bite can become fected. In the East and West African form the tick Ornithodoros moubata the transmitting agent.

The fatality in European relapsing fever at all ages is about 4 per cent., but markedly increases with advancing years. In the very serious forms in which undice is present, the bilious typhoid of Griesinger (found in Egypt) and the ndian type the death-rate may exceed 50 per cent. Season appears to have ttle influence in determining prevalence, but more cases, on the whole, occur the colder months. The disease is rarely encountered except in association ith overcrowding and destitution.

Rheumatic Fever—This disease accounts for five out of every velve deaths from heart diseases in hospitals; in 1921 11·7 per cent. f the deaths at all ages in England and Wales were due to heart isease.

Although rheumatism is ubiquitous, temperate climates in which ere are considerable alterations in humidity favour the infection. n late autumn and early spring cases of rheumatism tend to increase number. Poynton and Paine consider cold damp houses importnt in the etiology.

Newsholme in the Milroy lectures of 1895 claimed a distinct lationship between deficient rainfall and prevalence of rheumatic ver, and drew attention to the marked irregularity in the recorded ortality (as shown mainly by hospital statistics), with a tendency special prevalence at intervals of from three to six years. It is ow generally held that the disease is due to a specific organism, icrococcus rheumaticus, isolated by Poynton and Paine from twelve ccessive cases of rheumatic fever; the organism on intravenous oculation into rabbits produced the clinical appearances of that isease including synovitis, polyarthritis, inflammation of the cardiac alves and pericarditis without any suppurative changes; chorea and horeiform movements were also observed.

The micrococcus is obtained with least difficulty from inflamed ynovial membrane and has been isolated from the tonsils in cases f rheumatic fever, from vegetations on the cardiac valves and occaonally from the fluid in the joints.

Of especial interest is the cultivation of the organism from the erebro-spinal fluid in three patients suffering from chorea and its etection in the membranes of the brain; this points to chorea being mild meningo-myelitis produced by the micrococcus. The organism usually considered to be a streptococcus growing in short chains; the tissues it usually grows in pairs.

Poynton and Paine have shown that "scarlatinal rheumatism" due to an invasion of the system by the rheumatic infection which ives rise to rheumatic fever.[1]

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[1] "Researches on Rheumatism," Poynton and Paine, p. 299.

The disease can be transmitted by a pregnant mother to the child in utero In a series of 1,800 private cases, W. B. Cheadle found a family history in 58 per cent. The female sex is more vulnerable than the male; of 500 cases collected by Poynton and Paine, 319 were females and 181 males.

Almost any age is liable to an attack, but although acute rheumatism occurs at the age of two years or under, it is not till after five years the numbers of those affected begin to increase rapidly. Below 12 years of age rheumatism is essentially an infection of the heart. In adolescence and early adult life the liability to the disease is less than in childhood and the manifestations are less varied.

The results of rheumatic infection are of grave importance.

In twelve months from July, 1919, to June, 1920, of 172 in-patients with rheumatic manifestations under 12 years of age at the Hospital for Sick Children, Great Ormond Street, 84 were suffering from first attacks. 33 of these came under notice for chorea, 9 for arthritis, 5 for primary cardiac disease and 37 for multiple manifestations. By September, 1920, of these 172 patients, the number dead was 22, 30 were chronic invalids, in 58 the heart disease was compensated, recovery had occurred in 62.

Tonsillectomy has been widely advocated as a preventive of first attacks; the administration of salicylates in the early stages is held by some to prevent the heart being attacked.

Rubella—The existence of a form of disease presenting some similarity to both measles and scarlet fever, but quite distinct from them, was already suspected more than a century ago. The opinion has been entertained by some writers that this malady, to which the name Rubella, or German measles, has been applied, must be regarded as a hybrid of scarlet fever and measles; apart altogether from this hypothesis there can be no doubt that many cases of so-called German measles are really aberrant forms of one or other of the two more familiar diseases, or are mere instances of error in diagnosis. We now know that a distinct specific malady does exist, and that it may be distinguished by certain special characteristics which it possesses; particularly the character of the rash and the enlargement of the lymphatic glands, especially the posterior cervical group; the disease breeds true, an attack of rubella does not protect against either measles or scarlet fever or *vice versâ*, one attack of rubella protects against another of the same disease. It must be admitted that the diagnosis from mild cases of scarlet fever or true measles is at times difficult. Dukes and others have of recent years maintained that there is yet another form of specific ailment to which the term "Fourth Disease" has been applied.[1]

Rubella is in comparison to measles a rare disease. Epidemics when they occur usually take place in the spring and early summer, a relatively large proportion of those affected are over ten years of age and are adults.

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[1] But see Ker, p. 82, "Textbook of Infectious Disease."

The incubation period is usually eighteen days, the extremes being twelve and twenty days. A prodromal period exists, during which the disease is infectious; it is often marked by slight catarrh and sore throat; in a few instances vomiting and shivering; stiffness of the neck and enlargement of the cervical, occipital and axillary glands frequently appear before the rash.

The disease is less markedly infectious than measles, and it is hardly ever fatal. Infection is probably conveyed by the breath. The period of infectiveness lasts for about seven days after the first appearance of the rash. The micro-organism which causes the malady has not been isolated, and nothing has been learnt concerning the spread of the disease by the agency of milk, or food, or as to its affecting any of the lower animals.

Scarlet Fever—Little is known as regards the early history of scarlet fever. In the sixteenth century epidemics of what may have been this disease occurred in parts of Italy, and Ingrassias, in 1556, and Sennert, of Warsaw, in 1622, described cases of the malady. Sydenham, in 1676, wrote a chapter on it. He observes that it is scarcely worthy of the name of a disease, and makes no reference to sore throat in connection with it. Morton held that it was merely confluent measles, and throughout the eighteenth century there appears to have been a tendency to refer all but the milder forms of scarlet fever to the category of malignant sore throat. Thus Fothergill, in his account of the "putrid sore throat," written in 1748, speaks of a case in which a plentiful eruption of small pimples induced those about the patient to apprehend it was a common scarlet fever; again, some of the cases described by Huxham, of Plymouth, a few years later, as malignant ulcerous sore throat, were undoubtedly scarlet fever, as it is noted with regard to them that desquamation and dropsy occurred. Heberden, in his Commentaries, in discussing "angina and scarlet fever," says, "where it happens that the throat is full of little ulcers, attended with considerable pain, there the disease, though the skin be ever so red, is not denominated from this colour, but from the soreness of the throat, and obtains the name of the malignant sore throat; and many suppose that the two disorders differ in nature as well as in name. Of this let the reader judge when he has considered the histories of both."

In 1821 Bretonneau described and named diphtheria; but it was not until 1855 that scarlet fever was distinguished from diphtheria in the Registrar-General's returns. In 1859 a considerable prevalence of membranous sore throat occurred, and the mortality registered as due to diphtheria rose to 517 per million living, while that referred to scarlet fever was 976 per million living. From 1859 onwards, major prevalences of scarlet fever were developed at intervals of four or five years, the mortality in 1863 and 1864 was upwards of 1,400 per million living; in 1869 and 1870 the disease proved fatal to almost as great an extent; in 1874 the mortality was 1,050 per million; again in 1878 it was 753 per million. Then followed a marked decline with, occasional exacerbations, but in 1887, a year of comparatively high mortality, the rate only reached 282 per million, and on the next occasion, when a maximum was attained, in 1893, the rate was only 235 per million. Thus "the nineties," as compared with "the eighties," and again "the eighties," as compared with "the seventies," and "the seventies," as compared with "the sixties," show marked diminution in the rate of mortality from scarlet fever. After 1906 the mortality from scarlet fever fell below 100 per million, and from 1916–20 below 40 per million. The diminution was accompanied from the "seventies" till the "nineties" by a steady though smaller increase in the registered mortality from diphtheria.

The disease especially prevails in North-West Europe and in North America; it is comparatively rare in Africa and Asia, but occurs in parts of those continents bordering on the Mediterranean. In this country it is much more destructive, as a rule, in cities than in rural areas, and it especially affects the industrial and, more particularly, the mining counties. The explanations suggested by the Registrar-General, is that in these counties the population is more closely aggregated, and hence the spread of infection is facilitated. As he remarks, however, this "is not true as regards diphtheria, nor does it seem altogether true as regards measles."

The question of *periodicity* in scarlet fever has already been referred to. The *case-mortality* varies much in different epidemics. Graves, of Dublin, early in the last century, commented upon the marked variation in the fatality at different periods. In recent years the case-mortality observed in the Metropolitan Asylums Board Hospitals in London has steadily declined. For the six years (1887 to 1892) the average case-mortality was 8·35 per cent.; while for the six years (1891 to 1896) it had fallen to 4·7 per cent. This decline, it should be noted, has been accompanied by a large increase, commencing in the early "eighties," and becoming very marked from 1887 onwards, in the proportion of deaths occurring in these hospitals, to the total deaths in London. Moreover, changes of nomenclature may be, in part at any rate, accountable for the decrease. The case-mortality rate in London as a whole in 1924 was only 1·1 per cent.

Climate and Season—The fact, that the disease appears unable to establish itself in the tropics, suggests that climate influences its prevalence. Ballard, some years ago, pointed out that in this country "a temperature above the average for the season, and a dry state of the atmosphere with little rain, favour the presence of scarlet fever more than the reverse conditions." Longstaff, in 1880, drew attention to the striking similarity of the curves depicting fluctuations in mortality, during the years 1855–80, from diseases belonging to what he styled the "scarlatinal group." The diseases in question (pyæmia, puerperal fever, erysipelas, rheumatism of the heart, scarlatina, laryngitis, quinsy, croup, and cynanche maligna) exhibited, throughout these years, variations in recorded mortality in close correspondence with one another. The elevations and depressions, so well marked in the scarlatina mortality curve, were more or less traceable in all the others; there was also noticeable, in the case of each individual curve, a tendency to exhibit an inverse relationship to the rainfall, dry periods corresponding to increased mortality, and periods of heavy rainfall to diminished mortality. On bringing the investigation up to date, subsequent to 1890, the resemblances indicated were found to be not so closely maintained in the later period of years.[1]

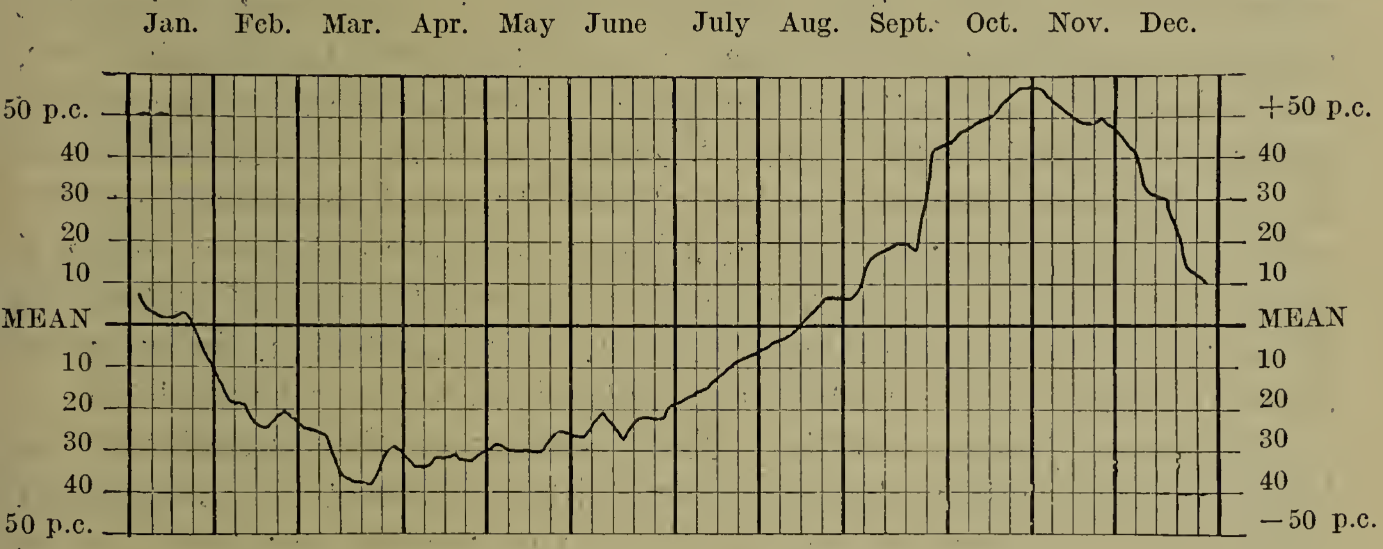

Fig. 80.—Scarlet Fever in London (forty years, 1861–1900).
The mean line represents an average weekly number of thirty-seven deaths.
(*After Shirley Murphy.*)

The above figure depicts the London curve of mortality for the years 1861–1900. In New York the curve differs markedly from this, the maximum being in April and the minimum in September. It may here be noted that Whitelegge found, at Nottingham, that fewer cases of scarlet fever were notified on Wednesday than on any other day of the week, a fact which he attributed to diminished likelihood of infection, owing to the cessation of school attendances upon Sundays. The seasonal curve shows no trace of diminution of *mortality* following upon holidays, but the London curve of *notifications* for individual years presents, as a rule, a well-marked "August depression," in correspondence with the cessation of school operations during the summer holidays.

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[1] The subject of the relation of diphtheria to rainfall has been elaborately investigated by Newsholme in his work on "Epidemic Diphtheria."

Seasonal variations in fatality—Scarlet fever, as tested by hospital statistics, was found by Whitelegge to present variations corresponding with the cyclical fluctuations, in mortality from the disease, observed during the "sixties" and "seventies." As regards seasonal variations in case-mortality, it would appear from statistical records that the relationship is an inverse one, the disease being least fatal during the months when it is most prevalent. On the other hand, Gresswell found evidence, from study of cases in one of the Metropolitan Asylums Board's hospitals, to the effect that the graver manifestations of the disease became more frequent and more marked during September, October, and November, and then underwent mitigation. Shirley Murphy has investigated the seasonal variations in fatality as exhibited in London, and finds that the case-mortality is lowest from July to October. He has, moreover, pointed out that the figures show that there is a seasonal variation in the age-distribution of scarlet fever cases. Thus, children under 5 years of age constitute a greater proportion of the total cases in the early part of the year, and this proportion falls to a minimum in September, subsequently rising to the end of the year. "There is arrest of this fall in the month of August, due to the fact that children of the school age are not then contracting disease in schools, and that children under 5 constitute, therefore, a larger proportion of the total cases." That the closing of the schools in August had an obvious effect in limiting the spread of the infection in the 1920 epidemic is held by Brownlee.[1]

Influence of Age and Sex—The liability of the unprotected to infection was small in the first year of life, increased to a maximum in the sixth year, and becomes smaller; the greatest number of cases occurs from 5 to 10 years of age. After 15 the number of cases is small, but the disease can be contracted at any time of life. The chance of an attack being fatal is greatest in infancy; it then diminishes up to the end of the twenty-fifth year, after which it again somewhat increases. Females, speaking generally, are found to be more subject to attack than males after ten years of age, but attacks in males, though fewer, were more liable to terminate fatally. The actual mortality observed attains a maximum in the third year of life, the diminution at later ages being due (*a*) to the increased proportion in the population at each successive age-period, of persons protected by a previous attack; (*b*) to the diminution of liability to infection in successive age-periods, of those as yet unprotected; and (*c*) to the diminishing risk in successive age-periods of an attack, should it occur, proving fatal. As the Registrar-General says, these results show, "independently of the plain fact that a very large proportion of persons go through life without ever contracting the disease, that the longer an attack is deferred the less likely it is to occur at all;

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[1] See "Lancet," November 27, 1920, p. 1093.

and not only so, but that, even supposing it to occur eventually, the less likely it is to end fatally."

Dissemination—The disease is infectious from the appearance of the first symptoms. Observations discredit the hypothesis that the desquamating cuticle is mainly responsible for the spread of infection; late desquamation in the fifth and sixth weeks is now disregarded. The discharge from mucous surfaces, suppurating glands or even wounds and possibly the urine must be regarded as infectious.

Providing the patient is free of all catarrh and discharges no harm accrues if he is allowed to leave hospital at the end of four weeks. In a certain small proportion of patients the infectious condition may be of long duration, persisting after apparent recovery; it may also revive after it has ceased, *e.g.*, when the patient contracts nasal catarrh. The difficulty is often met by advising the friends of all scarlet fever patients discharged that for a further three weeks the patient should sleep in a separate bed and use separate handkerchiefs and towels, and that during this period he should not be kissed on the lips and should not mix with other children. The breath and oral secretions are often, no doubt, the means of conveying the disease; also articles contaminated with such secretions. In schools the chewed end of penholders, paint brushes and pencils used in common have been held responsible for spread; in the home there are numerous instances recorded, too, in which clothing, etc., put aside for a time when the patient sickens, but not adequately disinfected, has appeared to possess the property of transmitting scarlet fever. Nesbit has, however, recently traced the books in a public library during a scarlet fever epidemic over an extended period, and in no case could infection be ascribed to this source. Inquiry has shown that the malady exhibits no special incidence upon houses in the neighbourhood of fever hospitals, and infection cannot, therefore, be conveyed aerially for considerable distances, as is the case in small-pox. Scarlet fever has never been found to be spread by water; it is frequently, however, transmitted by the agency of infected milk.

The chief sources of spread are mild undetected cases and to a far less degree healthy carriers. When all the children in a large family contract scarlet fever it may happen that one or more of the children suffer from no more than a sore throat; also an antecedent history of sore throat in another member of the family is not unrarely obtained during the routine inquiries in cases of scarlet fever. It would seem very probable that these sore throats are manifestations of scarlet fever and as such are infectious. It has long been thought that healthy carriers occur; the Reports on Return Cases of Scarlet Fever (and Diphtheria) to the Metropolitan Asylums Board of 1898–99, 1901–2, 1902–4, record 88 instances of such carriers presumably healthy on discharge from hospital causing return cases. But children who never have had the disease can transmit it to others.[1] Relapses occur but in less than one per cent. of the cases; second attacks are not infrequent, but only after a considerable number of years. The incubation period of scarlet fever is usually two to three days, the limits being twenty-four hours and seven days.

Scarlet Fever Milk-borne Epidemics—Hart collected 15 epidemics of milk scarlatina; Busey and Kober tabulated 59. Trask gives details of 51, making a total of 125 epidemics spread through the medium of the milk supply.[2]

In nearly all the outbreaks in which the actual means of infection has been traced, the infection has been derived from a recognised case of scarlet fever insufficiently isolated from direct or indirect contact with the milk or from an unrecognised case of scarlet fever among those coming into direct contact with the milk. Less frequent outbreaks are due to the infection of milk vessels, bottles, etc., with the specific organism of scarlet fever. The place of infection may be anywhere in the course of the passage of the milk to the consumer.

Another possible source of infection is from specifically infected or infective cows.[3]

The Hendon Outbreak—In December, 1885, an outbreak of scarlet fever was traced to milk supplied from a Hendon farm, and the inquiry made by Power into the circumstances is of such importance as to require special consideration. Investigation as to antecedent disease among the Hendon population failed to give any positive result, and the farm itself was "sanitarily perfect." The question, therefore, arose whether the cows themselves "had something or other to do with any scarlatina which had been distributed along with their milk."

In the absence of other explanation of the way in which infective property could have been imparted to the milk, inquiry was instituted as to any new condition pertaining to the cows coincidently with acquirement of ability of their milk to produce scarlatina.

It was found that on the 15th of November three newly-calved cows from Derbyshire arrived at the Hendon farm, and on the 4th of December four additional cows were received from Oxfordshire. In the third or fourth week of November, the milk allotted to one of the milk rounds, which was specially affected from the beginning of the outbreak, was derived from two of the four sheds at the farm, described as the "large" and the "middle" sheds; that sent to a second milk round also early affected, came in part from the "middle" shed and in part from the "small" shed; a third round not at first involved was supplied from the "small" shed. The 15th of November cows had been placed on their arrival at the farm in a fourth shed known as the "quarantine" shed; their milk being sent on the first and second rounds, but rarely if ever on the third round.

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[1] An outbreak of scarlet fever at Addenbrooke's Hospital, Cambridge, ascribed to a healthy carrier, is described by A. J. Laird in the "Medical Officer," June 30, 1923. See also C. V. Chapin, "Sources and Modes of Infection," p. 109.

[2] P. 59, *et seq.*, Bulletin No. 56, Public Health and Marine Hospital Service, U.S.A., Milk and its Relation to the Public Health (1909).

[3] This question is also discussed in addendum to Chapter VI of "Milk and the Public Health," Savage, pp. 115, 117.

On the assumption that the milk of these 15th of November cows was infective, the incidence on two rounds, and the exemption of the third would, therefore, be explained; but, as Power pointed out, if the above concurrence was, in truth, indicative of cause and effect, it must be possible to set down, *a priori*, "certain other parallel events which, if they had occurred, would greatly strengthen the inference." The events at the farm (transference of cows from one shed to another, etc.) were thereupon examined in detail and a sequence of occurrences was discovered which, when considered in relation with the scarlet fever incidence in the different districts, was quite consistent with the hypothesis that the cow malady was the cause of the infective property being communicated to the milk.

The nature of this infective cow malady was investigated from the bacteriological side by Klein, who found that some of the viscera of the affected cows presented diseased conditions similar to those observed in fatal cases of scarlatina in man, and that a streptococcus, which he called the *Streptococcus scarlatinæ*, could be isolated from material derived from the affected cows, from the blood of persons suffering from scarlatina, and from internal organs of persons dying of scarlatina. He further found that subcultures, derived from man or from the cow, produced, when inoculated into calves, "every manifestation of the Hendon disease, except sores on the teats and udders"; that subcultures inoculated into recently-calved cows produced the characteristic ulcers on the teats; that in rodents, subcultures, whether from man or from the cow, produced identical effects, and that calves fed on subcultures established from human scarlatina developed the Hendon disease.

Much controversy arose as to these results. An eruptive disease of the teats and udders of cows in Wiltshire, which did not give rise to scarlet fever, was investigated by Crookshank, who arrived at the conclusion that this disease was cow-pox. Klein pointed out that the Hendon disease differed from cow-pox in the more rapid course of the eruption, the more pronounced infiltration of the corium, the shorter duration of the crust stage, and the more speedy progress of healing. Again, the appearances on inoculation of calves differed in the two maladies, while in the Hendon disease sores did not develop on the milkers' hands, and there was distinct visceral disease in the affected cows. Klein further investigated eruptive maladies of the cow (associated with spread of scarlet fever, or infectious disease resembling scarlet fever, to man), which were observed in Camberwell, in Glasgow, and in Edinburgh.

The advances made during recent years in our knowledge of the mode of spread of infectious disease, and especially the demonstration of the part played by the "human carrier"—although free possibly of all symptoms and even of history of disease—are matters that cannot fail to raise the question whether such carrier agency can be entirely excluded in these early outbreaks of scarlet fever in which milk was the vehicle of infection.

On the other hand, a degree of certainty hitherto lacking would be arrived at if we were able to accept the view that the particular micro-organism isolated by Klein alike from the Hendon cows and from patients suffering from scarlet fever, was beyond all question the specific principle of scarlet fever. Further evidence at present available as to the nature of this infective agent may be summarised as follows:—Direct bacteriological examination by a plurality of investigators has long since established the constancy and abundance of streptococci in the faucial secretion during the early angina of scarlet fever, and also the presence of micro-organisms of this class in the complications of this disease. It would appear also that in the majority of the cases that succumb to scarlet fever a streptococcal septicæmia obtains. Streptococci, however, are also present in large numbers in the secretion of the normal mouth, and are met with in septic conditions of all sorts. Before the significance of the particular streptococci occurring in scarlet fever could be ascertained, therefore, it was necessary to study the whole group of these micro-organisms, and to obtain if possible some improved means of differentiating them from one another. The researches of Gordon, Andrewes and Horder, and others, served to show that the streptococci met with in disease-processes in the human subject can be differentiated by their morphological, cultural, fermentative, and pathogenic characters into three main groups—*salivarius*, *fæcalis*, and *pyogenes*. Specimens of the two former groups are normally present in the alimentary canal and are to be obtained (in disease) from the blood in a proportion of cases of malignant endocarditis; Streptococcus pyogenes occurs in septic conditions of all sorts, including erysipelas, and is often present as a secondary invader in conditions due primarily to other micro-organisms. A ready means of differentiating pyogenes from the other two groups was introduced by Schotmüller who showed that whereas examples of S. pyogenes are hæmolytic in culture, other streptococci are not.

When this information came to be applied to the study of scarlet fever it was found that the particular streptococcus which is present constantly in the faucial secretion during that disease could not be distinguished in the characters mentioned from S. pyogenes. More recently, however, by employing serological means of differentiation it has been found by Tunnicliff and Bliss in America, and by Gordon in this country that this hæmolytic streptococcus present in scarlet fever is distinct serologically from examples of Streptococcus pyogenes occurring in conditions other than scarlet fever. Further evidence bearing on this matter has recently been brought forward by the Dicks of Chicago who claim to have succeeded in producing typical scarlet fever in human volunteers by infecting them with this scarlatinal streptococcus. The Dicks have also found that the filtrate of a broth culture of this same streptococcus gives rise to a definite local reaction when injected into the skin of persons susceptible to scarlet fever, while those who are immune to scarlet fever give a negative result. The Dick test for scarlet fever thus promises to have a field of application analogous to that of the Schick test in case of diphtheria. Still further evidence of the close association of this particular streptococcus with scarlet fever has been brought forward by Dochez, who has shown that the serum of a horse prepared against the products of the streptococcus in question causes a blanching of the scarlatinal rash, whereas a similar serum prepared in the same way against the products of S. pyogenes has no such action. Although the matter is still *sub judice*, these recent advances have materially strengthened the claim of the scarlatinal streptococcus to be regarded as the specific micro-organism of that disease.

Anti-scarlatina serum has been produced by Dochez and Stevens by immunising horses with living streptococci; this serum has given results in treatment apparently comparable with those of anti-diphtheria serum.

This serum when injected into the skin of most scarlet fever patients blanches the rash at the site of infection (Schultz-Charlton reaction). Active immunisation can be carried out with scarlet fever toxin.

Isolation—The isolation of scarlet fever has for some years been extensively practised, particularly in this country, and as the system of removal to special hospitals, accompanied by disinfection of rooms occupied by the patient, clothing, etc., has been more and more perfected, the *mortality* from the disease has steadily declined.

During the years 1870–90 isolation was mainly confined to the larger towns, but the decline in mortality had barely commenced in these large centres of population when it was also manifested throughout the country generally, including towns and rural districts in which no attempt at isolation had been made. This is hardly matter for surprise, inasmuch as the spread of the disease in sparsely populated districts is admittedly, to a considerable extent at any rate, facilitated by the importation of infection from more thickly populated areas, in which scarlet fever always, to a greater or less extent, prevails.

It has been further objected, however, that comparing one country with another, mortality has fallen in those which have not attempted to combat the disease by preventive measures, as well as in those that have. J. T. Wilson, in a thesis published as a supplement to "Public Health" (1897), concludes, on an extended survey of the movement of scarlet fever mortality, that some more widely operating influence than mere isolation must have been at work in bringing about the reduction that has taken place. The utility of isolation hospitals for scarlet fever has been questioned on the ground that the incidence of the disease has not been lessened by their use. But it may be urged that some of the factors which contribute to the spread of the malady may yet remain in uncontrolled operation. Newsholme points out that

> "The control of scarlet fever is a matter of minimising the opportunities for infection in recognised and also suspected cases. This necessity involves a minuteness of supervision which cannot always be secured largely owing to the fact that an insufficient medical staff is employed. . . . It is evident that the question of hospital isolation cannot be considered separately from that of other administrative efforts in each district for the efficient control of scarlet fever. Thus the supposed inefficiency of the isolation hospital in a given locality may in part at least be due to failure in complete disinfection or to insufficient search for undiscovered cases or to carrier cases presenting the phenomenon of protracted infection."

The conclusions derived from McClure's analysis of 8,341 cases of scarlet fever occurring in Manchester during the four years 1909 to 1912 [1] was that a very definite advantage accrued from removing cases of scarlet fever to hospital, when other susceptible persons remain in the infected household ; in hospital cases the mean incidence rate per 1,000 was 119·9 and in the group remaining at home 156·2. He also demonstrated that the longer the removal of the patients is delayed the greater is the incidence on the remaining susceptibles. The argument may in some respects be considered academic, consideration is not given to the skilled treatment and nursing in such institutions, nor to the disabilities, inconveniences and pecuniary losses which the presence of patients suffering with infectious disease in a household entails; the public opinion of the labouring classes would not allow of the abandonment of hospital isolation of scarlet fever.

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[1] See "Public Health," June, 1914.

The Milne treatment has been proposed as a substitute for hospital isolation. The treatment is as follows:

"As early as possible in the illness the throat is swabbed with carbolic oil, frequently on the first day or two.

The patient is gently rubbed all over the body from the crown of the head to the soles of the feet with pure eucalyptus oil once morning and evening for the first four days, and afterwards once a day until the tenth day of the disease.

By this method of treatment it is claimed that infection ceases from the time treatment is applied and that the cases run a milder course, complications are rare, and the patient can be nursed at home without danger to other members of the household."

The method has been exhaustively tried in fever hospitals; the results have shown that the infection is certainly not killed, the number of return cases, cases of cross-infection and complications were not diminished by following this method of treatment.

Return Cases—Hospital administration has been criticised in connection with the occurrence of "return cases" of scarlet fever and diphtheria. In instances in which a child has returned from a fever hospital, and shortly afterwards [1] another inmate of the house has been attacked by the disease, it has, perhaps, not unnaturally been assumed that the second person was infected by the returned convalescent, and it has then further been concluded that the hospital administration has been at fault. The fact must not be lost sight of, however, that, having regard to the large scale on which isolation has been practised in recent years, a certain number of instances in which the sequence of events referred to has occurred might be expected to be forthcoming, apart altogether from infection by the hospital case; moreover, it is probable that some so-called "return cases" may be really attributable to newly bringing into use imperfectly disinfected garments. Again, "the possible influence of school attendance in its relation to alleged return cases is, perhaps, especially deserving of attention," and "the possibility of alleged return cases being part and parcel of a milk outbreak should also, of course, be borne in mind."

With regard to the influence in this connection of school operations, a report by T. W. Thompson on return cases of scarlet fever is particularly instructive. Questions as to the general character of the households from which patients were sent to hospital, and as to excess in them of persons of the ages most susceptible to scarlatina, and of scholars at public elementary schools, were regarded by this observer as having had some share in determining the preponderating incidence of secondary scarlatina on particular households in Bromley and Beckenham in the years 1892–4. He did not find "sufficient evidence to show the extent to which, if indeed at all, such cases were attributable to defective hospital administration," though he thought it not improbable that overcrowding of the hospital wards might have contributed to the production of secondary cases. He further drew attention to the influence of season, and to that of the stage of the epidemic, as probably having important concern with the occurrence of "return cases."[1]

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[1] Most writers only include those secondary cases occurring within 28 days of the return of the patient from isolation, others include all secondary cases occurring within longer periods, *e.g.* six weeks.

W. J. R. Simpson reported in 1899 to the Metropolitan Asylums Board on "Return Cases of Scarlatina and Diphtheria." He found that during the six months October 1, 1898, to March 1, 1899, 6,507 cases of scarlet fever and 3,275 cases of diphtheria were discharged from the Board's hospitals; during the same period there appeared, within a month, in houses to which discharged cases were returned, 253 fresh cases of scarlet fever and 86 of diphtheria. "There occurred at the same time in the districts of London 13,955 cases of scarlet fever and diphtheria, so that the 339 secondary cases arising in houses subsequent to the arrival of primary cases discharged from hospital, were equal to a percentage of 2·4 on the total number notified, or 2·8 for scarlet fever and 1·9 for diphtheria.[2] The incidence varied much in different parts of London, it attained a maximum in Battersea, where secondary cases of scarlet fever represented 8 per cent. of the total notified cases, and secondary cases of diphtheria amounted to 5 per cent. of the notified diphtheria cases.

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[1] See 24th Annual Report of M.O. of the L.G.B.

[2] If during six months cases of scarlet fever or diphtheria occur, say, in 2,000 houses per month (*i.e.*, in 12,000 houses), it may be calculated how many re-invasions of houses involved during a particular monthly period might be expected, as a mere matter of coincidence, assuming that every house in London was equally likely to be invaded. Thus the total number of houses being taken as 600,000, the number of such re-invasions in six months would approximately be $\frac{2,000}{600,000} \times 12,000$, or 40. It is obvious that all the 600,000 houses are not equally likely to be invaded: many contain no susceptible persons, or even if there be susceptible persons in them there is no likelihood, owing to freedom of the locality in which the house is situated from disease, of infection being acquired. Having regard to the limitation of scarlet fever to particular areas, in milk outbreaks, school outbreaks, etc., and to the greater risk in localities where the population is closely aggregated and so on, it is clear the above-mentioned 40 must fall considerably short of the number which chance, and chance alone, would explain. It may be assumed, moreover, that a certain number of cases affect houses previously invaded owing to the persistence of some source of infection in the home environment, and quite independently of hospital influence. That something more than the mere play of chance is concerned in the production of "return cases" is, however, proved by the fact, that study of multiple notifications shows secondary cases are notified, from houses, more frequently during the period of eight weeks, from the eighth to the fifteenth week, after the notification of a first case, than they are during the eight weeks comprising the fourth to the seventh and the sixteenth to the nineteenth weeks, after such first notification. This distribution in time suggests that returned hospital convalescents may in rare instances promote the spread of disease. Niven fully discusses the subject of "return cases" in his Annual Report for 1901.

On making personal inquiry concerning the 339 secondary cases, Simpson found that in 123, or 36 per cent., there was no evidence to support the conclusion that they were return cases; thus in some instances the secondary cases occurred immediately before the primary cases returned home; or, again, the secondary case was one of a different form of disease from that affecting the supposed primary case. In other instances some other probable source of infection was heard of—infected clothing, toys, etc.; and in the remaining cases there was no evidence "from either the condition of the primary case or in the circumstances under which the illness of the secondary case took place, to show that the infection was connected with the return home of the primary." Again in thirty-six cases the evidence was of a doubtful nature; while in seventeen others it was impossible to dissociate infected clothing, etc., or house infection, from personal infection.

There remained 159, or rather less than half the total number of cases, which Simpson classed as "probably due to personal infectivity of the primary case." He noted that the primary infective scarlet fever cases were more than twice as numerous as the diphtheria cases; that the percentage of primary infective cases did not greatly vary when the eleven individual hospitals discharging cases were separately considered; and that the variation, such as it was, did not appear in any way to be connected with shorter detention of the patients in the hospitals concerned; further, that while only in rare instances was desquamation present in the primary infective cases, in at least four-fifths of these cases discharge from one or other mucous membrane was found to be present. Of the infective primary cases the majority had not been isolated for a specially brief period, and in one instance the supposed primary case had actually been detained eight months in hospital. Simpson attached much importance to the mucous discharges to which reference has been made, and he advanced the hypothesis that these discharges do not themselves possess infectious properties, unless it be by acting as suitable media and carriers for any possible infection that may come in contact with them. His reasons for thinking that the secretion, *per se*, is not infectious, but that it has been rendered infective by accidental contamination, are:

1. That the ward itself is in an infective state.
2. That the infective property does not continue long when the patient returns home, though the discharge continues.

3. That when there is a recurrence of the discharge some time after the return home of the patient from hospital, the patient is not infective, and
4. That a large number of children with discharge from the ear or nose go home without infecting anyone else.

Simpson refers to the need of caution with regard to the use of warm baths immediately before discharge in winter, and to the desirability of issuing instructions to parents, so that suitable precautions may be taken when the patient returns home; he also thinks that more attention might be paid to the disinfection of clothes by steam, and advocates, on the whole, a reduction rather than an extension of the duration of the period of detention of scarlet fever and diphtheria cases in hospital. This report, and the observations made upon it by the medical superintendents of the various hospitals, were considered by a committee of the Royal College of Physicians. The committee commented on the small percentage of the cases found to have given rise to fresh infections, and considered that possibly too much importance had hitherto been attached to the infectivity of the skin during the later weeks of scarlatinal convalescence. With regard to the question of infectivity of the mucous discharges, the committee suggested that further inquiry should be made. "If," they say, "it can be proved that the discharge after a time constitutes simply the vehicle, as suggested by Simpson, and is not in its nature infective, as is usually believed, it is obvious that the practice of removing the patient from an infective environment for a short period before return to his home is one which should be adopted."

In A. G. R. Cameron's report of 1904 he mentioned that the supposed infecting cases were 4·1 per cent. of the total number discharged from the M.A.B. hospitals; since then this figure has been reduced.

It must not be forgotten that "return" cases occur equally when patients are treated at home. In Brighton during seven years (1909–15) 2,496 hospital cases of scarlet fever gave rise to 75 secondary cases (3 per cent.) within the period of six weeks of the return of the patient home; during the same time 382 cases treated at home gave rise to 14 (3·7 per cent.). H. Kerr's figures show that during the years 1913–23 the return and incidental cases in connection with Newcastle-upon-Tyne hospital cases were equal to 9·0 per cent. of the susceptibles left at home, those in connection with home-nursed cases were equal to 10·8 per cent. of the susceptibles left at home.

The home conditions to which a patient returns should be taken into consideration, it would seem probable that they have a marked influence on the number of cases infected by scarlet fever patients after their discharge whether from hospital or from home. Supervision and isolation as far as practicable of the patient who has given rise to the return case is an obvious precaution.

Small-pox—*History*—There is considerable reason for supposing that small-pox prevailed in Hindustan and in China before the Christian era, and the practice of inoculation is said to have been introduced in the last-named country in A.D. 590. As regards Greece

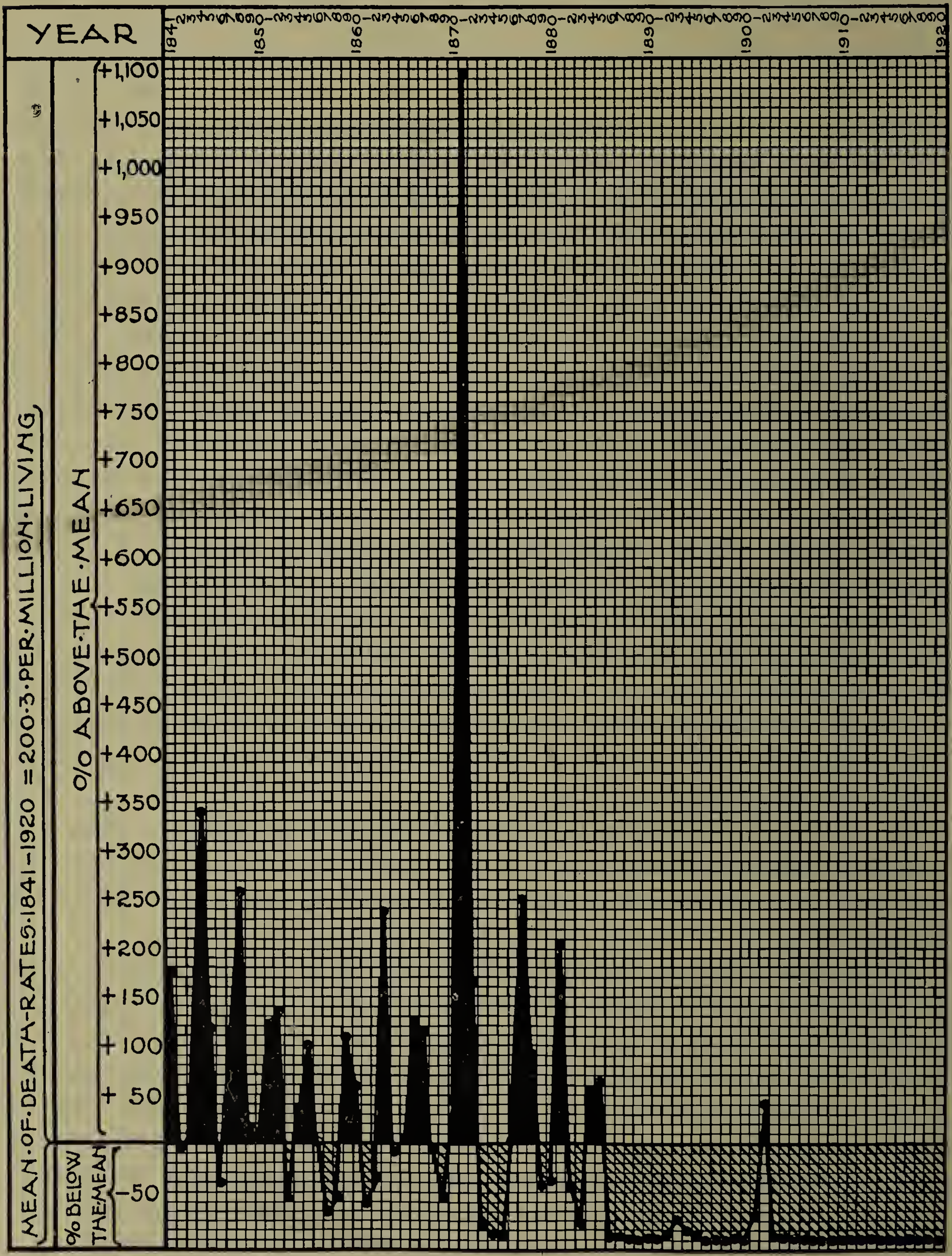

FIG. 81.—Mortality from Small-pox, London, 1841–1920.

and Rome, the existence of outbreaks of the malady cannot be definitely proved or disproved. Rhazes, who died about A.D. 923 or 930, wrote a treatise on small-pox and measles, and it is clear that small-pox was well known to other Arabian physicians. In Europe in the Middle Ages the accounts given, in annals kept in various monasteries, make it probable that the disease from time to time prevailed. Certain early references in Irish records have in particular been cited in proof of this. In Iceland numerous outbreaks are said to have occurred from the thirteenth century onwards. In England, indications of a detailed and precise character are not forthcoming in the Middle Ages. In the Elizabethan period the disease was already well known, and the earliest Bills of Mortality show that small-pox was thoroughly established in London; indeed, from 1629 onwards it appears to have been constantly present.

The malady caused somewhat higher mortality in the eighteenth than in the seventeenth century; the highest proportion of deaths attributed to the disease was attained in 1796, when out of a thousand deaths from all causes included in "the bills," 184 were ascribed to small-pox. This proportion probably understates the actual facts, as it is doubtful whether deaths from small-pox under two years of age were included in the returns. There was a steady decline subsequent to the introduction of vaccination in 1798; but a considerable prevalence, though one of comparatively small proportions when gauged by the eighteenth-century standard, again occurred in 1838. Then followed rather more than thirty years of relative freedom from the disease, though during this time outbreaks, of comparatively small magnitude, developed at intervals of three to five years. In 1871 a considerable prevalence occurred, the death-rate per million in England and Wales being almost as high as it had been in 1838. In the years subsequent to 1871 small epidemics prevailed at intervals of four or five years, the last of this series of any considerable importance being that of 1885, when 104 persons per million in England and Wales died of small-pox. Then followed a period of markedly lessened prevalence of the disease, though in 1893 the mortality in England and Wales reached 49 per million living. In 1901–2 small-pox again manifested ability to spread in London on a considerable scale, the rate in 1902 almost equalling that of 1885.

The vast bulk of informed opinion holds that the mild cases of disease occurring in recent years in this country and called by some alastrim (or amaas) were definite small-pox. Alastrim and amaas are in all probability identical with small-pox.

Geographical Distribution—Small-pox has occurred from time to time over almost the whole inhabited globe, though in Australia and in New Zealand it has hitherto never attained anything like the proportions of an epidemic. In parts of Africa and of Asia it appears to be almost constantly present, and, in particular, Egypt, Nubia, Abyssinia, and the Soudan, on the one hand, and Persia, Arabia, and India, on the other, have been spoken of as endemic foci of the disease.

Seasonal Prevalence—In this country, small-pox tends to be above the mean in the first half of the year, and below it in the latter half. In the East the spread of the malady appears to be less marked in hot seasons, and to be favoured in cold seasons. *Soil and Climate* seem to have little or no influence upon small-pox. As regards *Race*, it may be noted that negroes are peculiarly susceptible.

Age and Sex—Males suffer at almost all ages to a greater extent than females. The question of age-incidence is largely affected by the periodicity of epidemics, a point which has been already referred to. Moreover, the remarkable variations in age-incidence which have occurred, as vaccination has been more and more thoroughly and extensively put in practice, will have to be later considered.

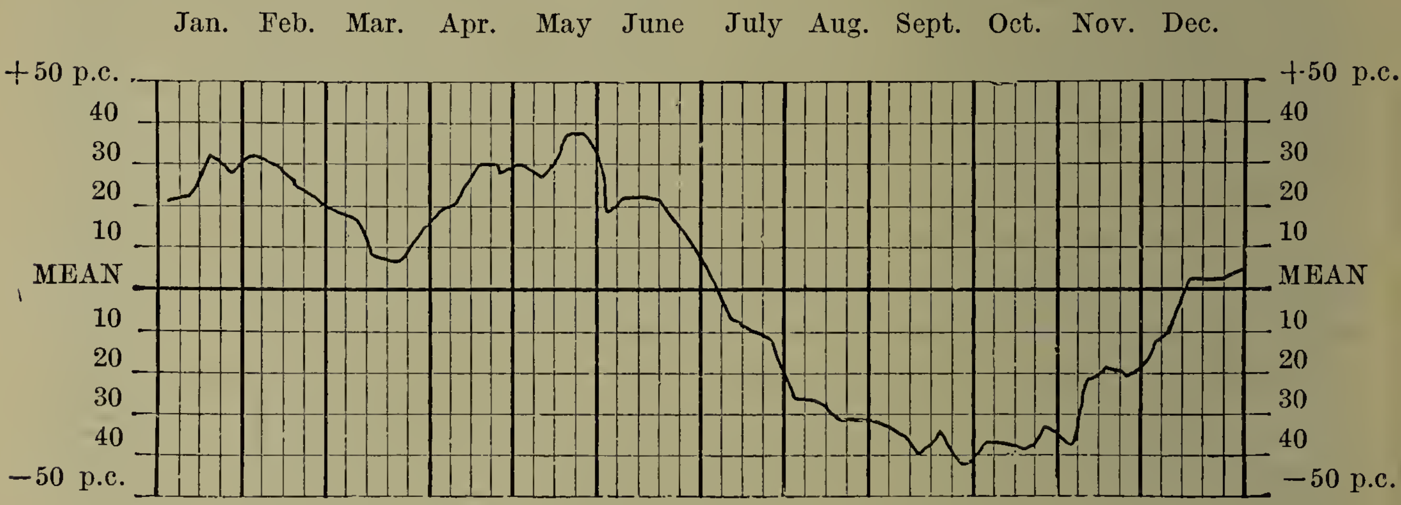

FIG. 82.—Small-pox in London (sixty years, 1841–1900).
The mean line represents an average weekly number of fourteen deaths.
(*After Shirley Murphy.*)

Dissemination—Infection is probably conveyed in most instances by the breath; it is also transmitted by clothing, rags, etc. Dust from infected raw cotton has been held responsible for small outbreaks at Oldham and Milnrow in 1914.[1] The researches of Power have shown that the disease may be aerially transmitted through considerable distances, under certain favouring conditions, indeed a marked incidence of the malady upon persons living in houses situated even from three-quarters of a mile to a mile from a small-pox hospital, acting as an infecting centre, has been repeatedly observed (see p. 306).

The *incubation period* is usually twelve days, the initial symptoms commonly appearing on the thirteenth, and the rash on the fifteenth day. The latent period may be, however, longer or shorter than that specified, by four or five days, and the rash is sometimes delayed until the fourth day. Translated into practice this means that in order to trace the origin of the infection (and so often to discover missed cases) inquiry must be made concerning the movements of the patient during the three weeks preceding the commencement of his attack and particularly on the 12th, 13th, and 14th days prior to the onset of his illness.

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[1] "Annual Report L.G.B., 1913–14," p. liii.

The *case-mortality* of small-pox varies in different epidemics; the disease is said to be specially fatal when it affects populations it has not previously attacked. Age exerts considerable influence, the fatality being high in infancy, decreasing to a minimum between the tenth and the fifteenth years, and then increasing fairly steadily again as age advances. Hence the distribution in ages, of susceptible persons, in a particular population attacked, materially influences the fatality observed in individual outbreaks. In the eighteenth century Jurin collected particulars concerning some 18,000 cases, which showed an average case-mortality of 16 to 18 per cent. In the one instance—that of Aynho, in Northamptonshire—in which the ages at death are given, most of the cases occurred at from five to twenty-five years of age, and no mention is made of deaths under two years of age. McVail has suggested that "Jurin did not knowingly set down any deaths under two years old as due to small-pox," but relegated them to other headings, and that his percentages are irretrievably damaged by this omission. Whatever may be the correct interpretation of Jurin's statistics, there can be no question that the fatality of the disease among unvaccinated persons, as observed in hospitals since precise records have been collected, has been considerably higher than 18 per cent.; indeed, it has been found to be from 30 to 40 per cent. or more at all ages.

The protection afforded by an attack of natural small-pox is considerable, but by no means absolute throughout life.

Inoculation of small-pox virus was found to be followed by the appearance of a small papule on the second day; this became vesicular, with evidence of depression, as a rule, in the centre of the vesicle, on the fifth day. On the seventh day the vesicles contained pus, and the central depression was more marked; an areola was developed, which enlarged, as a rule, up to the tenth day; within its area secondary pustules usually appeared. The pustule was commonly observed to dry up after about a fortnight, and the crusts separated from the end of the third to the beginning of the fifth week. Inoculation was introduced in this country in 1721, and the practice was gradually extended. One operator alone, Daniel Sutton, claimed, in 1796, that he had inoculated 100,000 persons. The "Suttonian method" appears to have consisted, essentially, in taking material exclusively from the "mother pustule"—*i.e.*, before the general eruption had appeared.

VACCINATION

The history of small-pox in the nineteenth century is intimately bound up with the subject of vaccination; and the influence which this last-named operation exerts upon the disease must be considered in detail.

The course run in an ordinary vaccination is as follows: A small elevation develops on the second or third day. On the fifth or sixth day this pustule becomes a vesicle, and presents a slight central depression; but this does not become so marked as in the case of inoculation of the small-pox virus, and secondary pustules do not later appear, as has been noted to be usually the case in inoculation. The vaccine vesicle attains maturity on the eighth day, when it is full of clear lymph, and is surrounded by an areola, which may ultimately extend until its diameter is from one to three inches. About the tenth day the fluid of the vesicle, now opaque, begins to dry up, and a scab is formed, which separates, leaving a scar, at the end of about three weeks. The phenomena in revaccination differ from those already described. The maximum effect may be produced on or before the fifth day; vesiculation may never be observed, or the vesicles, if formed, may abort, and the scabs may separate early. The areola extends, however, more widely, as a rule, and glandular enlargement and considerable febrile disturbance may be produced.

The incubation of vaccination is shorter than that of small-pox, and hence, according to Marson, successful vaccination, within three days of exposure to infection, may altogether prevent an attack of the disease, and, even as late as the sixth day, the attack may be distinctly modified. It was the practice until recently to vaccinate from arm to arm; an animal station, providing for vaccination directly from the calf, was established, however, by the English Government in 1881. Copeman, in 1891, called attention to the desirability of employing glycerinated lymph. The glycerine rapidly destroys extraneous organisms; but for a time the lymph still manifests ability to produce characteristic appearances at the site of inoculation, and it is assumed that its protective properties are not materially impaired. Glycerinated calf lymph is now largely used for the purposes of vaccination.

The grounds for concluding that vaccination profoundly modifies, if it does not altogether prevent, a subsequent attack of small-pox, may be considered under the following heads:

I. The reasons which originally led to the belief that vaccination affords protection against small-pox—Towards the end of the eighteenth century the notion was entertained, by dairymen and others in places where cow-pox prevailed, that persons who had suffered from cow-pox were protected against subsequent attack by small-pox. Benjamin Jesty, a Dorsetshire farmer, in 1774, inoculated his wife and sons with cow-pox material, with a view to affording them such protection. Edward Jenner, when an apprentice in Gloucestershire, about 1768, had heard of the belief held by the dairy folk, and he instituted a prolonged investigation into the matter, and at length, in 1798, published his " Inquiry into the Causes and Effects of the Variolæ Vaccinæ."

In this treatise he recorded nineteen instances, which he had observed of persons who had accidentally acquired cow-pox, and who appeared subsequently to be incapable of taking small-pox, their insusceptibility being deduced from their failing to contract the disease on being exposed to it, or from the fact that they did not respond to the " variolous test "—*i.e.*, to inoculation with small-pox material. Jenner, moreover, gave particulars concerning the inoculation of a boy (Phipps) with cow-pox material in 1796. He described the appearances produced at the site of inoculation, and the failure of the variolous test when tried six weeks later, and again, when applied after an interval of some months. Further, Jenner related how, in 1798, he inoculated a child with cow-pox material; from this child another child; from this again several children; from one of these a fourth in succession, and then a fifth. In three of these children the variolous test was applied with a negative result.

The College of Physicians reported on vaccination to the House of Commons in 1807, and as the result of their inquiry, " felt it to be their duty strongly to recommend the practise of vaccination." Further, vaccination was extensively practised on the Continent. Thus, as McVail remarks, " all over the civilised world thousands of persons who had not undergone a certain preliminary operation were inoculated with the virus of small-pox, and with a very small percentage of failures all received the disease; and simultaneously all over the civilised world, thousands of persons who had undergone the preliminary operation in question, were also inoculated with the virus of small-pox, and with a very small percentage of exceptions all resisted the disease." It has been observed that the tests applied by the early vaccinators were " equal in value to the experiments carried on in the biological laboratories of the present day; while in number they were infinitely greater."

II. The behaviour of smallpox subsequent to the introduction of vaccination—In the Final Report of 1896, this matter is discussed under two heads; the earlier period (1800 to 1825) being first dealt with, and then the period since 1825.

A. The London " bills " and the records of small-pox mortality which are forthcoming from other parts of the country, the Swedish figures which date from 1774, those of Copenhagen, which extend back to 1750, and the available statistics relating to other countries of Western Europe and to the United States, all indicate that the first quarter of the nineteenth century was marked by a great diminution of small-pox deaths. In Sweden, " from 1801 onwards, there is a fall, becoming great after 1809." In Copenhagen " small-pox was prevalent up to 1801, then suddenly declined ; indeed, for a while it quite disappeared, no deaths being recorded between the years 1810 and 1824."

It has been urged that the introduction of vaccination tended to cause the abandonment of inoculation, and that inasmuch as inoculation had increased the amount of small-pox, the diminution of the disease, in the first quarter of the nineteenth century, is explicable as resulting from decrease of inoculation. The Vaccination Commissioners deal with this objection in paragraphs 64–75 of their Final Report. They point out that the increase of mortality from small-pox during the eighteenth century occurred in its first quarter, when there was no inoculation at all, and during the second quarter, when there was very little, to as great or an even greater extent than during the third quarter, when inoculation was most prevalent. Moreover, as they note, it should be borne in mind that inoculated small-pox was, on the whole, much less fatal than the naturally acquired disease ; and they refer to records which indicate that inoculation, when carefully practised, may materially diminish mortality from small-pox. They say " the general conclusion which may be drawn seems to be that inoculation had a double influence, the one favourable, the other unfavourable, as regards small-pox, and owing to the conflict between these two influences it produced but little effect upon the prevalence of, or mortality from, small-pox."

Another suggestion which has been made is that the decline of small-pox, which followed the introduction of vaccination, was due to improved sanitary conditions ; a similar diminution did not, however, occur in the case of measles, but, on the other hand, there was a marked falling off in the number of deaths returned as being caused by " fevers." As regards this last-mentioned phenomenon, however, altered nomenclature was probably largely operative ; indeed, " scarcely any heading in the bills can be less safely trusted as an indication of the conditions affecting disease " ; further, the decline was observed not merely in this country, but in other countries where the sanitary conditions were widely different.

The Commissioners in summarising the evidence say, " The decline in question followed upon the introduction of the practice of vaccination. The records of Western Europe and the United States show that, in all places whence returns were obtained, the introduction of vaccination was followed by a decline of small-pox, the decline becoming especially apparent after the lapse of such time as may be supposed to be necessary for the due spread of the practice; moreover, the spread of the practice and the decline of the disease do not stand as two phenomena simply following the same course, but without any tie joining the two; the experimental evidence offered at the time—namely, that the class of vaccinated persons did not take small-pox, by way either of exposure to natural contagion or of inoculation, as the unvaccinated did—connects the two and points to the spread of the practice as the cause of the decline."

It further appears, from such information as is available, that in countries where vaccination did not become general the decline did not occur; and, with regard to the objection that the decline observed was out of all proportion to the amount of vaccination that prevailed, it has to be borne in mind that, in the early part of the last century, only a small portion of the population needed to be protected by vaccination, inasmuch as at that time large numbers of persons had been rendered immune by previous attacks of small-pox, either natural or inoculated.

B. The statistical data which have accumulated, during the last three-quarters of the nineteenth century, afford a mass of material for study in connection with the protective influence of vaccination against small-pox. In England and Wales the registration of deaths commenced in 1837, in Scotland in 1855, and in Ireland not until 1864. In the later years of the century, observations made at small-pox hospitals and special reports upon particular outbreaks of the disease became available. The facts may be examined under several heads.

(*a*) VACCINATION LEGISLATION AND SMALL-POX MORTALITY—In 1840 an Act was passed to extend the practice of vaccination, by which the guardians and overseers of parishes were empowered to contract for the performance of vaccination. The same Act made inoculation of small-pox illegal. In 1841 it was enacted that the expenses of carrying out the Act of 1840 should be chargeable to the poor-rate, but that no disability or disqualification should attach to any person vaccinated by the parish officer, or to whom surgical or medical assistance, incident to the vaccination, was rendered by him.

In 1853 vaccination was made compulsory and enforceable by penalty, but no adequate machinery for carrying the law into effect was yet provided. The Act of 1867 authorised the appointment of paid vaccination officers, and the Act of 1871 made the appointment of such officers compulsory in all Unions. From 1872 onwards records have been kept by the Local Government Board showing the amount of vaccination, performed within a certain period of birth, in children whose births are registered during each year. The published tables exhibit, for each year, the number of births and give the figures relating to those successfully vaccinated, those certified as insusceptible, or as having had small-pox, and also the number of those dying unvaccinated, or having vaccination postponed by medical certificate.

The children not finally accounted for, including cases postponed, constituted, as a rule, from 1872 to 1883, rather less than 5 per cent. of the births; the percentage then gradually increased in the later eighties and attained to 22·3 in 1896. The diminution in the percentage of children vaccinated since 1883 "did not, of course, necessarily result at once in a diminished proportion of the population who had at some time in their lives been vaccinated." Broadly speaking, the proportion of children primarily vaccinated steadily grew from 1840 onwards, with an augmented rate of increase after 1853, and again, even more notably, after the years from 1868 to 1872. The proportion must, however, have diminished from shortly before the year 1890, onwards.

There has been in England and Wales a notable decline in the small-pox death-rate; in "the fifties" as compared with the earlier period, and in "the sixties" as compared with "the fifties." In 1871 and 1872 the death-rates were in marked excess, attaining to figures comparable with those of the earliest years of the registration period; in the remaining years of "the seventies" the decline was again continued, and it became more marked in "the eighties" and in the closing years of the century.

A table was prepared by the Registrar-General, and printed in his Forty-third Annual Report (p. xxii), in illustration of the changes which had occurred in the death-rate from small-pox at successive periods of life. This table, brought up to date, was presented to the Vaccination Commission, and is given on opposite page.

The figures show that coincidently with the gradual extension of vaccination there has been notable decline in the mortality at all ages, further that the decline has been exclusively among persons under 15 and most of all among children under 5. The criticism has been made that the division into periods, adopted by the Registrar-General, tells in favour of vaccination inasmuch as the prevalence of 1871 and 1872 falls largely within the second period, whereas it is urged it should have been included in the third period. Having regard to the fact that a large proportion of those attacked in 1871–2 were persons of the higher ages, and that many of them were born before 1853, when vaccination was optional, the contention appears to be beside the mark; indeed, for the purpose of examination of age-periods attacked, which was the question the Registrar-General

Mean Annual Deaths from Small-pox at successive Life Periods, per Million, living at each Life Period, 1847–53, 1854–71, and 1872–87.

Period.	All ages.	0–5.	5–10.	10–15.	15–25.	25–45.	45 and upwards.
1. Vaccination optional, 1847–53[1]	305	1,617	337	94	109	66	22
2. Vaccination obligatory but not efficiently enforced, 1854–71 . .	223	817	243	88	163	131	52
3. Vaccination obligatory but more efficiently enforced by vaccination officers, 1872–87	114	242	120	69	122	107	47

had in view, the classification adopted seems altogether free from objection. With regard to the "suggestion" which has been made that the division should be made by the law of 1867, and not by that of 1871, the inclusion or exclusion, of the figures of the 1871 outbreak, can of course be shown to affect the figures of groups of a few years, surrounding, and including or excluding, that date; speaking generally, however, there has been, since 1838, a marked though irregular decline in the death-rate from small-pox, though this decline has not been shared alike by the population at every age; indeed, at higher ages there has been actual increase in the death-rate. This question of altered age-incidence will be further considered almost immediately.

In Scotland, gratuitous vaccination had been provided since 1848, but it was not until 1863 that vaccination was made compulsory. Returns, relating to the primary vaccination of children, show that between 1864 and 1893 the number unaccounted for was only about 3 per cent., with, in later years, a slight increase to over 4 per cent. From 1855–64 the small-pox mortality varied between 11 and 58 per 100,000 living; after this there was a marked decline; then there was marked prevalence during the years 1871–4, followed by a sudden decline; and no considerable prevalence again occurred during the remaining years of the century.

In Ireland, in 1840–1, as in England and Wales, provision was made for vaccination. The law was amended in 1851 and 1858, but it was not until 1863 that vaccination was made compulsory. Further Acts were passed in 1878 and 1879. Approximate figures relating to the death-rate in Ireland are available for 1831–41, 1841–51, and 1851–61, the average annual rates per 100,000 living being 73, 49, and 21 in those periods. From 1864 onwards the deaths are precisely recorded, and show marked decline after 1864, then a rise corresponding to that noted in England and Scotland in the years 1871 and those immediately succeeding, and then again decline, with some irregularity, but becoming particularly marked after 1880.

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[1] In this table the period of optional vaccination begins with 1847, not with 1838, because the deaths were not abstracted in combination with ages until 1847.

The Vaccination Commissioners, in their Final Report, say—"It seems to us scarcely possible to deny that, speaking generally of the British Isles, a more vaccinated population has exhibited a diminished mortality from small-pox. It was not, of course, to be expected that this should be seen year by year, or that the correspondence should be exact, even assuming vaccination to be the principal cause of this diminished mortality. We have already pointed out that small-pox tends at times to become epidemic, *i.e.*, to spread more readily than at other times. The occurrence of the conditions, whatever they may be, which cause the disease to be thus epidemic has, of course, no relation to the state of the population as regards vaccination, even conceding to the full that it has a protective effect. The only result of widespread vaccination, in a case where small-pox become epidemic, would be to render the extent of the epidemic more limited, and its fatality less than it would otherwise be. All that we should anticipate, then, would be a general correspondence over a long series of years between a vaccinated condition of the people and a diminished mortality from small-pox."

It has been sought to find explanation of the decline which has occurred, in altered conditions of life and particularly in improvement of sanitary conditions. But, while influences which may have told in favour of a reduction of mortality have been at work, other influences which have undoubtedly had an opposite effect, such as increased aggregation of the population in towns, and greater facilities of intercommunication between different localities, have also been operative. Again, there has not been marked reduction of mortality in measles and whooping-cough, diseases which may be regarded as being comparable with small-pox. In the case of scarlet fever there has been, it is true, a notable decline, but this only commenced about the year 1880, and there are other circumstances which indicate that it in no way corresponds to the decline in small-pox mortality now in question; further it has been associated with the carrying into more and more complete effect of an elaborate system of dealing with scarlet fever cases. In the case of "fevers," too, the mortality has notably diminished; but here again altered nomenclature has undoubtedly been largely operative. Moreover, the causes which have mainly contributed to the diminution of malaria, and of typhus and enteric fever, have been to a large extent determined, and the facts which have been brought to light altogether discredit any attempt to institute comparison between the behaviour of these diseases and that of small-pox. Finally, the decline in small-pox mortality has been attributed to measures of isolation. Doubtless this factor has been largely operative in recent years, but it cannot be held to explain the phenomena of the extended period which has been passed in review.

(*b*) The Altered Age-Incidence of Small-pox—The remarkable facts which have been brought to light by study of the statistics of small-pox mortality in relation to age, yield altogether unmistakable evidence of the protective power of vaccination, while, at the same time, they indicate that the immunity afforded is not, as was at one time supposed, of a permanent character, but that after the lapse of some nine or ten years the protection against attack by small-pox becomes lessened. The influence of the operation in modifying the nature of the malady if it is contracted is, however, still manifested, as will be seen later, for a more lengthened period, and indeed, it would appear, throughout life. Later experience has shown that absolute protection is only conferred for five years.

The question of altered age-incidence has already been cursorily referred to. The discussion of the facts in detail is given in paragraphs 168–201 of the Final Report; only some of the main points can be touched upon. The Commissioners give the following table :—

England and Wales : Deaths from Small-pox at certain Age Periods to 1,000 Deaths from Small-pox at All Ages.

——	Under 1.	1–5.	5–10.	10–15.	15–25.	25–45.	45 and upwards.
1848–54	251	426	130	33	75	67	18
1855–59	231	328	144	37	117	112	31
1860–64	237	313	108	42	123	133	44
1865–69	231	314	103	33	126	145	48
1870–74	143	169	140	58	200	224	66
1875–79	112	129	113	72	218	266	90
1880–84	113	122	98	68	216	286	97
1885–89	112	81	54	51	229	344	129
1890–94	166	117	50	26	131	338	172

They comment as follows upon these figures :—

"The first point calling for notice is that in the period 1855–9, as compared with the earlier period, there was a considerable diminution in the share of small-pox mortality borne by those between one and five years of age. In the earlier period it was 426, in the later 328. As regards those under one year of age the share fell from 251 to 231. It must, of course, be remembered that, whatever the prevalence of vaccination amongst children, the age-period under one year will always contain a considerable unvaccinated class. We are naturally led to inquire whether there is anything in the history of vaccination to account for the remarkable change we have adverted to. In the year 1853 vaccination was made compulsory, and, though no sufficient means were provided for rendering the law effectual, it cannot be doubted that it was calculated to increase vaccination in the subsequent years.

"The next marked change is seen in the quinquennium 1870–4. The proportion of small-pox mortality borne by those under one year of age decreased from 231 to 143, and by those between one and five years of age from 314 to 169. We have already called attention to the fact that in 1867 power was given to the guardians to appoint vaccination officers, and that advantage was taken of this from time to time by different Unions, though a large number remained without such officers until after 1871, when their appointment was made compulsory. There can be no doubt that the effect of this legislation was to cause an increasing extension of the practice of vaccination in 1868 and subsequent years, and very largely to increase the amount of vaccination in and subsequently to the year 1871. The effect of this would be at once felt in the earliest age-periods, and at a period correspondingly later in the succeeding age-periods. We have already pointed out the marked change in the incidence below five years of age in the quinquennium 1870–4, and it will be seen that in subsequent quinquennia there was a diminished incidence in the age-periods 5–10 and 10–15, and later still in the period 15–25. During the last quinquennium there has been some increase in the incidence of the disease in the first two life-periods. This has been coincident with some diminution in the practice of vaccination."

On examination of the figures for a later quinquennium, 1895–9, it transpires that while the incidence on the age 0–1 had somewhat diminished (108 as compared with 166), the incidence on the age-period 1–5 had increased from 117 to 154, and the next age, 5–10, showed marked increase from 50 to 133. The figures for the remaining age-groups are 26, 107, 332, and 140. The wave of increased incidence had thus extended along the line and, in 1895–9, was already manifesting influence in the case of older children, the lapse of time having given opportunity for the growing vaccination default of the late "eighties" and early "nineties" to affect the death-rate at the ages 5–10 in the years 1894–99.

The Final Report also presents particulars concerning mortality at the several age-periods in a somewhat different form, the death-rates per million living in England and Wales being tabulated for the seven years 1848–54, and for each decennium since that date:

The figures for the seven years 1848–54 unavoidably include chicken-pox deaths, and it may be noted that such deaths are also included in the figures relating to the years 1848–54 in the previous table. This fact does not, however, materially affect the conclusions drawn, as the number of chicken-pox deaths, in those years, was beyond all question insignificant in comparison with the small-pox deaths.

England and Wales: Deaths per Million Living.

——	Under 5.	5–10.	10–15.	15–25.	25–45.	45 and upwards.
1848–54.	1,514	323	91	110	69	24
1855–64.	788·8	209·5	68·7	118·9	87·8	36·2
1865–74.	782·5	333·2	142·3	267·2	220·7	87·5
1875–84.	127·8	62·9	46·4	82·4	76·6	33·9
1885–94.	50·2	14·9	11·1	24·0	31·6	19·0

With regard to this table the Commissioners say:—"It will be observed that in the decennium 1855–64 there was a very large diminution of the mortality at the age-period under five years, a considerable, though smaller, diminution at the next age-period, and some diminution at the age-period 10–15. Supposing the compulsory law of 1853 to have augmented to some extent infantile vaccination, its effect would be felt in the class under 5 years of age during the greater part of the decennium. It would affect the class aged 5–10 years during the smaller part of the decennium, and the class aged 10–15 only during the last year or two. The next decennium, 1865–74, included the years of the great epidemic, to which allusion has already been made. Its effects are apparent in most of the mortality rates of those years. As compared with the preceding decennium, there was a very great increase of mortality at all the later age-periods. It is noteworthy that as regards those under 5 years of age the mortality was actually less, though very slightly so, than in the preceding decennium. And though there was increased mortality in the next age-period, the increase was less than in the later age-period. It is impossible not to be struck by this fact, when it is remembered that in 1867, and again in 1871, laws were passed calculated to increase the amount of infantile vaccination. The more stringent enforcement of the practice under these laws would considerably affect the class under 5 years of age during the decennium 1865–74, and the effect of the Act of 1867 would be felt to some, though only to a slight, extent in the class aged 5–10. Again, in the next decennium, 1875–84 the fall was very great in the mortality in the first two age-periods; it was reduced to 127·8 and 62·9 as compared with 1,514 and 323 in the years 1848–54, or with 788·8 and 209·5, making the comparison with the decennium 1855–64, when chicken-pox was not included. The results of the legislation of 1867 and 1871 would affect the class under 5 during almost the whole of this decennium, and would largely affect those in the next age-period. It would influence sensibly the class between 10 and 15 years of age, and slightly the next higher age-period. It would be without effect in the classes over 25 years of age. We find the mortality rate in these classes 76·6 and 33·9, being actually higher than in the years 1848–54, for which the figures are 69 and 24, and not much below the figures for the next decennium, viz., 87·8 and 36·2. Comparing, on the other hand, the rates at the age-periods 10–15 and 15–25, the figures are 46·4 and 82·4 as against 91 and 110 for the years 1848–54, and 68·7 and 118·9 for the next decennium. In the decennium 1885–94 there was much less small-pox than in either of the preceding terms of years with which we have been dealing. Isolation and measures of that description were, no doubt, having their effect. The decrease was, however, largest in the age-periods which would be most affected by the results of the legislation to which we have directed attention. Comparing the first and last terms of years, the reduction in the first three age-periods was from 1,514, 323, and 91 to 50·2, 14·9, and 11·1, in the age-period 15–25 from 110 to 24, and in the two highest age-periods from 69 and 24 to 31 and 19 only."

The statistics available in the case of Scotland and of Ireland present the same general features as those just commented upon. From Scotland, moreover, a very striking additional piece of confirmatory evidence is forthcoming. The Scotch Act requires that vaccination shall be performed within six months of birth. In England, until the Act of 1898 was passed, the operation was required to be performed within three months of birth. On contrasting, in the case of Scotland, the period 1855–63, the nine years prior to the Vaccination Act, with the period 1864–87, the twenty-four years subsequent to the Vaccination Act, it transpires that "the proportion of deaths borne by those under six months, who would be in both periods (substantially) an unvaccinated class, was almost exactly the same" (139 per 1,000 deaths at all ages in the earlier period, and 138 per 1,000 deaths at all ages in the later period). The proportion borne by those between six months and a year, and between one and five years, in the later period as compared with the earlier, was, however, "greatly diminished" (from 153 to 47 per 1,000 deaths at all ages, in the case of those between six months and a year, and from 413 to 137 per 1,000 deaths at all ages, in the case of those between one and five years of age). There was a slight increase (from 90 to 95) in the proportion per 1,000 deaths at all ages, but this increase was due, as is stated in the Final Report, "to the very large decrease in the proportion borne by those of an earlier age, and not to any increase of the mean mortality in the class aged five to ten in the later period, for the mean annual death-rate per million fell greatly, viz., from 244 to 86." At ages above ten, the mean annual death-rate was about the same in the two periods. The complete table from which these figures are taken is given in paragraph 174 of the Final Report.

The Final Report also contains a detailed discussion of the facts as to age-incidence, in six small-pox outbreaks, investigated by various observers, in Warrington, Sheffield, London, Dewsbury, Gloucester, and Leicester. In Leicester and Gloucester the child population was very ill-vaccinated, and the proportion of deaths borne by children, 0–10, was found to be high (71·4 and 64·5 per cent. of total deaths). In London and Dewsbury the child population was less ill-vaccinated, and the proportions in question were less high (51·8 in Dewsbury and 36·8 in London); it is noted that "the proportion of the unvaccinated in Dewsbury, may with confidence be asserted to have been greater than in London." In Warrington and Sheffield the child population was well vaccinated, and in those towns the proportion of deaths borne by children, 0–10, was low (25·6 and 22·5 per cent. of total deaths).

It has been sought to find explanation of the altered age-incidence of small-pox on the supposition that improved sanitary conditions have been operative. But a like altered incidence has not been observed in measles, whooping-cough, and scarlet fever. Tables, printed in the supplement to the Thirty-fifth Annual Report of the Registrar-General, have been appealed to as showing that, "whilst in Liverpool the percentage of deaths from small-pox expected under five years was 63·5 in 'healthy districts' it was only 25·5"; here, it is suggested, is proof of the effect of improved sanitary conditions upon age-incidence in small-pox. It is clear, however (see paragraph 197 of the Final Report), that the main influence at work is not any "sanitary condition," as the term is ordinarily understood, but proximity of population. In a large town, in which people are closely aggregated, the chances of contracting small-pox, measles, etc., are of course greater than in "healthy districts," which include, in the main, rural areas, in which the population is sparsely distributed.

The tables referred to also show, with regard to both measles and scarlet fever, that a larger proportion of deaths under five years of age occurs in Liverpool than in the case of "healthy districts." Again, "the comparison made between Liverpool and 'healthy districts' necessarily involves a fallacy unless it be borne in mind that, of a million born alive, a much larger number will attain ages beyond five years in 'healthy districts' than in a large town like Liverpool. The tables, indeed, show that 824,590 persons are estimated as living beyond the age of five years in the former, as compared with 539,630 in the latter. Hence, in the case of a disease such as small-pox, which is fatal at all ages, it necessarily follows that a larger proportion of deaths will occur, at ages above five years, in healthy districts than in Liverpool. The theory that "improved sanitary conditions" bring about the altered age-incidence in small-pox, therefore, proves on examination to be based on a misconception. The increased aggregation of persons in towns, which is so conspicuous a phenomenon of the nineteenth century, must have tended to increase the incidence of small-pox on younger ages, *i.e.*, to have actually acted in opposition to the influences which have thrown the excessive incidence of the disease upon the higher ages.

Stress has been laid on the fact that an altered age-incidence has been observed in the case of "fevers." This term, prior to 1869, included typhus fever, infantile fever, and remittent fever. Altered nomenclature and improved diagnosis have, no doubt, largely affected the returns of fever deaths. Enteric fever has been differentiated from the general fever group, and of late years typhus has become well-nigh extinct. It is of interest to note that, since 1880, remittent fever deaths, in children aged 0–5, have been taken out of the "fevers" group and relegated to remittent fever, and the use of the term "infantile fever" in classification has been abandoned. The percentages of deaths under five to deaths at all ages, in the case of typhus and typhoid, during four successive periods of five years since 1870 are as follows:—

	1871–75.	1876–80.	1881–85.	1886–90.
Typhus	6·4	6·1	3·5	3·4
Typhoid	17·4	16·0	9·3	7·5

These percentages show a sudden fall in the third period as compared with the second; the figures for the first and second periods, and for the third and fourth periods, being, however, in tolerably close agreement. The coincidence in point of time of this fall with the altered practice in regard to the classification of "fever deaths" is noteworthy. It is clear, then, that no change has occurred in the age-incidence of fevers which is in any way comparable with the change in the age-incidence of small-pox.

Appeal has further been made to the fact that the age-incidence of influenza differed somewhat, in the outbreak of 1890–1, from that observed in the outbreak of 1847–8. The comparison is based on the figures of only two years in each case, and the likelihood of error arising from the insufficiency of the data relied upon, is intensified, in dealing with the particular malady in question, by the fact that the cause of death may have been variously ascribed to pneumonia, bronchitis, and other headings, as well as to "influenza" itself. Moreover, the altered incidence, even for the limited periods considered, is not at all comparable to that observed in small-pox, which, be it noted, has been manifested over a long period of years. It is obviously irrational to assume that, because variations over limited periods are observed in the age-incidence of other diseases, therefore a notable and sustained alteration in the age-incidence of small-pox can be dismissed from further consideration.

(*c*) THE BEHAVIOUR OF SMALL-POX IN THE VACCINATED AS COMPARED WITH THE UNVACCINATED.

(i) *Case-mortality*—Mr. Marson, formerly Superintendent of the Highgate Small-pox Hospital, collected, during thirty-two years, particulars in respect of nearly 20,000 cases of small-pox. He found that the case-mortality among the unvaccinated was about 35 per cent.; while in those with four or more vaccine cicatrices it was only about 1 per cent. Dr. Gayton, who analysed the facts relating to upwards of 10,000 cases in Metropolitan Asylums Board hospitals, obtained similar results. Marson's and Gayton's tables (see page 506) will be more particularly referred to in connection with the protective influence of various degrees of vaccination. Sweeting collected particulars concerning 2,584 cases admitted to the Fulham Hospital between 1880 and 1885. His statistics corroborate the conclusions drawn from the other series of observations.

The six small-pox epidemics, commented upon in the Final Report, teach the same lesson. They include, taken in all, 11,065 attacks of small-pox, with 35·4 per cent. case-mortality in the unvaccinated, and 5·2 per cent. case-mortality in the rest of the population. Restricting attention to children under ten, the case-mortality in the unvaccinated was 36 per cent., while that in the remainder was 2·7 per cent. only. The objection has been raised that the unvaccinated class includes children under three months, in the case of whom an attack of the disease might be expected to be specially severe. The particulars collected enable such children to be excluded from the comparison instituted, and the figures then work out at a case-mortality of 30·3 per cent. in the unvaccinated, and only 2·8 per cent. in the vaccinated. "The contrast," it is noted, "is the more striking when it is remembered that all the doubtful cases are included in the vaccinated class, though many of them had in all probability never been successfully vaccinated."

It has been sought to explain these remarkable phenomena on the ground that the unvaccinated, as a class, are mainly drawn from the poorer and more neglected portion of the population. To some extent varying social conditions have no doubt been operative, but the difference observed is far too great to be thus accounted for. Moreover, "the disparity in the death-rate of those classed as vaccinated and unvaccinated was, in the six epidemics, greater nearer the date of vaccination than it was at a later period." The hospital statistics confirm this.

Again, it has been said the unvaccinated class includes children whose vaccination has been postponed for medical reasons. The number of such cases is, however, very small, and the postponement does not necessarily imply that the child is not ultimately vaccinated, or that if it remains unvaccinated, and is attacked by small-pox, it will, because of the fact that it suffered from some ailment in infancy, be less capable of resisting small-pox.

(ii) *Attack-rate*—This question was investigated on a vast scale by Barry, in the Sheffield outbreak. From his results it transpires that, in Sheffield, the attack-rate among the unvaccinated was at least five times as great as among the vaccinated; while, restricting attention to children under ten, the attack-rate among the unvaccinated was fifteen or more times as great as among the vaccinated. In the Sheffield outbreak, and in four others, the facts as to persons, resident in "invaded houses," who were attacked by small-pox after the occurrence of the first case in the house, were also ascertained. The following table, which appears in the Final Report, gives the results obtained:—

—	Attack-rate under 10.		Attack-rate over 10.	
	Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
Sheffield	7·9	67·6	28·3	53·6
Warrington . . .	4·4	54·5	29·9	57·6
Dewsbury . . .	10·2	50·8	27·7	53·4
Leicester. . . .	2·5	35·3	22·2	47·6
Gloucester . . .	8·8	46·3	32·2	50·0

(iii) *Severity of Type*—This question was also made the subject of statistical study by Barry. The facts as to cases of disease, coming under treatment in the Sheffield hospitals, were presented by him in the form of a diagram. (See Stevenson and Murphy, Vol. II, p. 449.)

The table on p. 505, from the Final Report, gives the percentages in Sheffield and in three other outbreaks, the cases being grouped under the headings milder (including varioloid and discrete) and severer (including coherent and confluent):—

The study, therefore, of case-mortality, attack-rate, and type of disease, in the vaccinated and unvaccinated, points unmistakably to the conclusion that vaccination materially affects the behaviour

——		Milder.	Severer.
Sheffield	Vaccinated	82·8	17·2
	Unvaccinated	18·5	81·5
Dewsbury	Vaccinated	82·0	18·0
	Unvaccinated	23·1	76·9
Leicester	Vaccinated	81·4	18·6
	Unvaccinated	27·2	72·8
Warrington	Vaccinated	78·2	21·8
	Unvaccinated	29·4	70·6

of small-pox. Especially noteworthy as regards each of the three tests is the fact that "the difference between the two classes is much more marked in the case of children under ten years of age, who are nearer the period of vaccination, than it is in the case of persons of more advanced years."

(*d*) Case-Mortality and Severity of Type amongst Vaccinated Persons with Vaccination Marks of Different Quality—This question was first raised by the publication of Marson's observations on 3,094 cases of post-vaccinal small-pox occurring between 1836 and 1851. "Marson's Statistics" were later extended so as to include further experience of 10,661 cases occurring between 1852 and 1867. (See p. 506.)

Sweeting proceeded on somewhat similar lines; his table is given on p. 75 of the Final Report. The same subject was examined in great detail by Barry at Sheffield, and by other observers in more recent outbreaks (paragraphs 273–287 of the Final Report). Taken altogether, the number of cases classified, according to the character of vaccination marks found on the patients, exceeds 20,000. Combining the later results (to the exclusion of Marson's figures), it transpires that the case-mortalities obtained are, 6·2 per cent. with one mark, 5·8 per cent. with two marks, 3·7 per cent. with three marks, and 2·2 per cent. with four marks. Some attention has been paid of late years to the area of scarring and to the degree of foveation observed, and evidence that the protection afforded depends upon the extent of the area covered by the marks has been obtained.

It may be remarked here that the Commission stated their opinion that if the vaccination marks are of an area of half a square inch they indicate a better state of protection than if their area be at all considerably below this.

(*e*) Revaccination—Barry at Sheffield ascertained that the attack-rate among revaccinated persons was ·04 per cent. (27 attacks among 64,431 persons), as compared with 1·55 per cent. in the entire population. The attack-rate among persons who had previously

MARSON'S STATISTICS.

Cases of Small-pox classified according to the vaccination marks borne by each patient respectively.	Percentage of deaths in each class respectively uncorrected.		Percentage of deaths in each class respectively corrected.[1]	
	1836–51.	1852–67.	1836–51.	1852–67.
1. Stated to have been vaccinated but having no cicatrix	25·5	40·3	21·7	39·4
2. Having one vaccine cicatrix . .	9·2	14·8	7·6	13·8
3. Having two vaccine cicatrices. .	6·3	8·7	4·13	7·7
4. Having three vaccine cicatrices .	3·6	3·7	1·8	3·0
5. Having four or more vaccine cicatrices	1·1	1·9	0·7	0·9
Unvaccinated	37·5	35·7	35·5	34·9

Gayton tabulated the results obtained by him, between 1873 and 1884, on an analysis of 10,403 cases, in a somewhat different manner, and it will be noted that he gave for the first time the facts with regard to different age-periods.

GAYTON'S TABLE.

Ages. Years.	Vaccinated with good marks.			Vaccinated with imperfect marks.			Vaccinated, but no marks visible.			Not vaccinated.		
	Cases.	Deaths.	Per cent.	Cases.	Deaths.	Per cent.	Cases.	Deaths.	Per cent.	Cases.	Deaths.	Per cent.
0–2 .	4	0	0	32	3	9	22	9	41	276	181	66
2–5 .	57	0	0	150	18	12	96	38	40	401	202	50
5–10 .	206	2	1	532	27	5	207	40	19	510	180	35
10–15 .	439	5	1	939	32	3	214	42	20	317	74	23
15–20 .	606	12	2	1,037	66	6	205	39	19	204	86	42
20–25 .	389	11	3	843	100	13	167	56	34	174	83	48
25–30 .	189	12	6	529	80	15	116	35	30	105	56	53
30–40 .	147	14	10	526	78	15	137	49	36	103	42	41
40–50 .	29	4	14	186	33	18	85	24	28	49	21	43
50 . .	19	2	11	80	18	22½	46	20	43	30	13	43
All ages	2,085	62	3	4,854	455	9	1,295	352	27	2,169	938	43

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[1] The terms "uncorrected" and "corrected" are used to signify the inclusion or exclusion of those fatal cases of small-pox in which the patient suffered from some other disease which was superadded to the small-pox.

suffered from small-pox was ·13 per cent., a distinctly higher rate than that in the revaccinated. Detailed inquiries as to the police force, post-office officials, etc., in Sheffield were also made by Barry, and these and similar experiences yielded by other recent epidemics, show how marked is the protection resulting from recent vaccination.

Quite conclusive evidence of the value of revaccination is afforded in the case of hospital staffs, nurses and attendants. The facts, as to Leicester, Homerton, Fulham, and Highgate are given in paragraphs 319–22 of the Final Report. Two accounts forthcoming from Dublin and from Paris, which had been supposed to tell against the general experience in this country, are dealt with in paragraphs 323–8. At the Mile-end Infirmary, in 1902, thirty-one of the forty-two members of the nursing staff had been revaccinated before the outbreak of small-pox in London; four others were revaccinated on January 28 and 29, two unsuccessfully. None of these thirty-five contracted small-pox. The remaining seven were all attacked. Of these, three were not revaccinated, and the rest sickened with small-pox in two days (two cases), three days and six days respectively after vaccination.

The statistics of small-pox mortality in the British army and navy, and in the postal service are analysed in paragraphs 331–40 of the Final Report; their bearing on the question of revaccination should be noted. An extraordinary difference was observed in the mortality from small-pox in the German and French armies during 1870–1. In the Prussian army vaccination was supposed to have been compulsory on joining, since 1834, and there is no doubt the German army, as a whole, was better vaccinated than the French army, and that the former as compared with the latter, suffered to a very much less extent, during the years in question, from small-pox.

Very striking evidence of the value of revaccination is afforded by a study of the effect of the law of 1874, which made revaccination compulsory throughout Prussia. Since this law came into operation until the profound disturbances of administration in the crisis resulting from the War, small-pox was almost entirely banished from that country. In "*Blattern und Schutzpockenimpfung*," a publication issued by the German Imperial Health Office, diagrams are given illustrating the striking contrast between the behaviour of the disease in Prussia and Austria, and again in certain German towns as compared with other large cities of Europe; further, the facts as to prevalence and mortality from the disease in the Prussian, Austrian, and French armies, since 1867, are given, and the contrast between the former and the two latter forces, since 1874, is apparent; again, the differing mortalities in successive years in the army, and in the civil population, in Prussia, since 1834, are also exhibited.

Specially noteworthy, moreover, is the fact that of 1,194 small-pox deaths occurring in the German Empire (1886–98), 511 were those of children under two years of age. Thus, in this vaccinated and revaccinated community, small-pox has shown a remarkable tendency to prove fatal at this age-period. The German law requires vaccination to be performed prior to the completion of the calendar year following the year of birth of the child. Of the 511 children, 15 were returned as vaccinated, 138 as unvaccinated, and of the remaining 358, whose condition as to vaccination was not stated, the large majority, having regard to their age at death, must have escaped being protected by vaccination.

It has been urged that evidence unfavourable to revaccination is furnished by the fact that the mortality of males in this country (1851–80) exceeds that of females (and the argument has been applied, too, in the case of Germany), whereas more males may be assumed to be revaccinated than females. It must, of course, be borne in mind that the male population is more exposed to contagion than the female, and the better revaccination of males does not altogether counterbalance this greater risk. It is interesting to observe that the ratio of male to female mortality in 1871–80, as compared with 1851–60, decreases at ages higher than those belonging to the age-group 10–15 (presumably owing to greater prevalence of revaccination). With regard to Germany, it may be further noted that 938 out of a total of 1,194, or 79 per cent., of the deaths which occurred during the years 1886–98 were those of persons residing near the frontiers or in seaports.

The prevalence of small-pox in certain tropical countries where vaccination is said to have been practised has been held by some to lessen the value of vaccination. In some instances evidence is available that lymph rendered inert by the high atmospheric temperature has been used: in others, *e.g.*, the Philippines, the work has been entrusted to natives who have failed to carry out their duties.

III. The Relationship between Vaccinia and Variola—Jenner's view was that cow-pox was small-pox occurring in the cow. An argument urged in evidence before the Commission was to the effect that inasmuch as cow-pox and small-pox were two different diseases, it was therefore *a priori* improbable that one would confer immunity against the other. The attempt to communicate small-pox to the cow by way of the respiratory or digestive systems has not been crowned with success. In certain instances, however, results of a positive kind have followed upon the inoculation of small-pox material in the cow.

The Final Report states that the experiments in question may be relegated to three categories. The first of these includes cases in which vesicles resembling vaccine vesicles were produced, the matter from which, when carried through a second or third remove in the cow, and then transferred to man, gave results indistinguishable from those of ordinary vaccination. Such experiments have been conducted by numerous observers, including Thiele (1838), Ceely (1840), Badcock (1840–60), Voigt (1881), Haccius and Eternod (1890), King (1891), Simpson (1892), and Hime (1892).

In the second category are placed the experiments of Klein and Copeman, who obtained, on inoculation, not a distinct vesicle, but merely a thickening and reddening of the wound. Lymph obtained from the site of the operation, in a second, third, and fourth remove in cows, produced more and more marked thickening and reddening, and lymph from the fourth cow produced typical vaccinia in a child. Klein's observations were made in 1892, and Copeman obtained similar results in the same year.

The third category includes the experiments of Chauveau and others, who found that small-pox, inoculated in the cow "gave rise to a specific effect, which was not cow-pox, but was of the nature of small-pox."

As regards the cases in which results indistinguishable from those of vaccination were obtained, it has been suggested that there might have been accidental introduction of cow-pox matter into the wound; but this source of error was carefully guarded against in the later experiments, and the conclusion arrived at, in the Final Report, is that this accident could not have occurred in all the successful cases, *and that a transformation of small-pox into cow-pox really took place.* It would appear that one condition, favourable to the transformation, is that the animal used should be a calf not more than three or four months old.

It remains to be pointed out that while each one of the tests which have been applied, to ascertain whether vaccination has a protective effect, yields an affirmative answer, in order to estimate their value it is necessary to consider them in conjunction. As is pointed out in the Final Report, "the greater the number of tests employed, and the greater the number of cases to which they are applied, the more certain is it that the play of chance or the influence of other causes will be excluded, and the more safely may the conclusions to which they lead be acted upon. The cumulative force of a number of pieces of evidence all pointing in the same direction is very great indeed."

The nature and extent of the injurious effects alleged to result from vaccination have been the subject of much inquiry. Many varieties of disease have, at one time or another, been attributed to the practice of vaccination; but examination of records of mortality affords no evidence that prevalence, of any of the particular maladies specified, has been increased to an appreciable extent by the practice of vaccination. In individual cases injury and even death have, however, been ascribed to the operation, and doubtless in a few instances the vaccination wound has served, as any other wound might have done, as a means of introducing germs of disease into the body.

During the years 1886–91, 279 deaths were associated with the operation of vaccination: in many of these undoubtedly no causal relationship was demonstrable; but, on the other hand, it may be that a few cases, in which the vaccination wound permitted of germs obtaining access to the body, escaped being returned in certificates as due to vaccination. On the assumption that the one group of cases counterbalances the other, the deaths must be taken to have been in the proportion of one to 14,159 primary vaccinations. In Scotland the proportion of cases in which death was stated to be due to vaccination, during the years 1883–90, was less than this, being only one to 38,872 primary vaccinations.

Among the fatal maladies connected with vaccination, erysipelas accounts for nearly half the total deaths, and this disease, in conjunction with "blood poisoning" and allied conditions, monopolises two-thirds of the deaths. Erysipelas is a very fatal disease in infancy, and, inasmuch as at this time 2,000 children per million used to die of erysipelas during the first three months of life, it might be anticipated that a certain number of deaths would occur in children shortly after they were vaccinated, without there being any connection between the disease and the vaccination wound. In many instances, moreover, in which the facts have been made the subject of careful inquiry, it has been demonstrated, having regard to length of incubation period or to other circumstances, that the supposed connection was merely apparent; it has sometimes happened, when vaccination has been postponed for one or other reason, that a diseased condition has manifested itself, which would certainly have been attributed to the vaccination, if the operation had been performed at the appointed time.

In the Final Report attention is called to some of the possible causes of mischief in cases in which erysipelas has been associated with the act of vaccination. In some instances erysipelas was prevalent in the vicinity; in others the child was living under extremely insanitary conditions; again, in particular cases there was evidence of want of care and attention, and it was found that the wound had been rubbed by articles of dress, or that substances had been applied to it which might have acted as vehicles for the contagion. These considerations suggest that, by the adoption of antiseptic precautions and the use of carefully prepared lymph, the number of inflamed arms and of cases of erysipelas may be reduced to the point of insignificance.

In very rare instances syphilis appears to have been transmitted by vaccination. The infrequency of such a sequence of events is evidenced by the fact that it was generally believed by the medical profession, until comparatively recent years, that such transmission could not occur; but, on the Continent more particularly, cases in connection with arm-to-arm vaccination among soldiers, or with the use of lymph from syphilitic infants, have been recorded, and the possibility of infection being conveyed in the manner indicated is now accepted. Inquiry was made, on behalf of the Commission, concerning a number of supposed cases, but in almost all instances the alleged connection was proved not to exist. The subject is fully considered in paragraphs 425 to 430 of the Final Report, and the conclusion is arrived at that "where the antecedents of the vaccinifer are fully ascertained, and due care is used, the risk may for practical purposes be regarded as absent."

Any risk of syphilis is now removed by the routine use of calf lymph.

OTHER PREVENTIVE MEASURES

Appreciation of the value of isolation in preventing the spread of small-pox has greatly grown of late years. Account has already been given of the investigations of Power with regard to the use of intra-urban hospitals, and the decline of small-pox in London since 1885 need not be again alluded to. Reference may, however, be here made to what is known as the "Leicester system." In the town named the plan of quarantining the inmates of an infected house, in addition to isolating the patient, was originated in 1875. (See however, p. 513.) In the absence of power of compulsory removal, persuasion was, as a rule, found to be successful. Compensation for loss of work was given in some instances. Dr. Tomkins, of Leicester, "though, like his predecessors, regretting the increasing disuse of vaccination, bore testimony in his annual reports to the efficacy of the measures adopted in Leicester."

The conclusions expressed in the Final Report of the Vaccination Commission are: that the evidence "is inconclusive as to the relative merits of quarantine in hospital, or supervision of the exposed at their homes," and that "the influence of prompt isolation of the patient appears to overshadow any superior efficacy the one method may have had over the other": again, it is stated with regard to the system of isolation generally, that "what it can accomplish as an auxiliary to vaccination is one thing; whether it can be relied upon in its stead is quite another thing"; at the same time, "even admitting fully the protective effect of vaccination, it does not diminish the importance of measures of isolation or dispense with their necessity." (See the Final Report, p. 131.) Hence, the more general provision of isolation hospitals is advocated by the Commissioners, and they recommend that power should be given to sanitary authorities to give compensation for loss of wages, and generally to incur expenditure in connection with isolation, etc.

A noteworthy feature of small-pox outbreaks in recent years has been the way in which the disease has been introduced and spread by persons of the vagrant class. Among the recommendations contained in the Final Report (p. 132) were several dealing with the necessity of making common shelters subject to the law relating to common lodging-houses, and of giving special powers to local authorities for the purpose of controlling the spread of small-pox in such houses.

THE VACCINATION ACT OF 1898

This Act modifies previously existing legislation in certain respects. It provides that the age before which a child must be vaccinated shall be raised from three to six months. A parent may avoid having his child vaccinated if within four months of the birth he satisfies a magistrate that he entertains a conscientious objection to the operation, on the ground that it would be prejudicial to the health of the child. A certificate is then given, which the parent must transmit within seven days to the vaccination officer. A person can be only once penalised for non-compliance with an order directing him to have his child vaccinated, and defaulters, if imprisoned, must be treated as first-class misdemeanants. It is made the duty of the public vaccinator, if the parent require it, to attend the child at its own home; he must so attend, after giving at least twenty-four hours' notice, if the child be not vaccinated within four months of its birth; he must offer to use glycerinated calf-lymph, or other lymph supplied by the Local Government Board, and he must keep registers showing the origin of the lymph used. He may give a certificate of postponement if owing to the condition of the house or to the existence of infectious disease in the neighbourhood he deem it necessary to do so and he must inform the medical officer of health of the district of the course taken. Vaccination must be performed within six months of birth, save in those instances in which a magistrate's certificate is obtained, or the child dies or is attacked by small-pox, or three or more unsuccessful attempts to vaccinate have been made, or a medical certificate of postponement (to have effect for two months at a time) is given.

As regards repetition of proceedings the present position is governed by Section 2 of the Act of 1898. A parent may be convicted under Section 29 of the Act of 1867, and when the child attains the age of four years, if the law is still not complied with, an order may be obtained directing the parent or guardian to have the child vaccinated;

if the order is disobeyed the parent may be convicted and fined, and no further proceedings can be taken. Alternatively, proceedings may in the first instance be taken under Section 31 of the Act of 1867, and an order made; if that order be disobeyed a conviction may follow, but no further proceedings can be taken, even after the age of four years is attained.

At times of small-pox prevalence, the Local Government Board may require the Guardians to provide vaccination stations, and may modify the duties of the public vaccinator with regard to visiting, otherwise than by request. A register must be kept by every sanitary authority maintaining a hospital for small-pox, showing the condition, as to vaccination, of patients admitted.

The administration of the Acts is still vested in the Poor Law authorities. Instructions have been issued by the Local Government Board, dealing with precautions as to cleanliness, sterilisation of instruments, etc., and requiring the public vaccinator to "aim at producing four separate good-sized vesicles, or groups of vesicles, not less than half an inch from one another." The total area of vesiculation resulting from the vaccination should not be less than half a square inch. Re-vaccination is not made compulsory, but persons over twelve (or over ten if there is immediate danger of small-pox), are to be re-vaccinated gratuitously.

During an epidemic it is advisable that all persons likely to come into contact with small-pox cases should be re-vaccinated unless this has been successfully performed within the last five years.

The Public Health (Small-pox Prevention) Regulations, 1917, authorise the M.O.H. or any assistant M.O.H. to vaccinate any willing persons who have been in contact with small-pox. The M.O.H. is to inform the public vaccinator and the vaccination officer of even a suspected case coming within his notice. (See also Memo. 71a of Ministry of Health, November, 1922.)

The modern view is that quarantining of contacts in the house is not necessary except in rare instances as when places such as laundries and common lodging-houses are involved, then the Ministry will sanction a reasonable expenditure for the purpose. The contacts are to be allowed to follow their ordinary occupation, but are to be kept under medical observation for 16 days: this means in practice that they are seen daily and their temperature taken. The Ministry hold that when small-pox is prevalent the making of chicken-pox compulsorily notifiable is a valuable aid to the discovery of missed cases or doubtful cases of small-pox. The M.O.H. should see as many as possible of the cases so notified.

Steps are taken to prevent any avoidable contact with infected towns, *e.g.*, important football matches, festivals, etc., bringing large numbers of persons into infected areas are abandoned on the representation of the local sanitary authority.

Sprue (*Psilosis*) chiefly affects Europeans who have lived in Southern China, Cochin China and Java. India, Ceylon, the West Indies, the Philippines and tropical Africa are also seats of the disease; it is rare in natives. The disease may not be manifested until the return home from the Tropics. Sprue is a form of afebrile diarrhœa characterised by periods of improvement alternating with a return to the previous condition. The onset is insidious; soreness of the buccal mucosa and vague digestive disturbances are soon followed by ulcers at the site of the back molars and a bare raw tongue. Voluminous frothy stools are passed chiefly in the morning hours. Unless treated early the disease tends to end fatally.

The disordered assimilation may be the result of infection of the alimentary tract or to diminished activity of the pancreas. No conclusive evidence of any infectivity is forthcoming.

Tetanus occurs especially in horses and in men; other animals are occasionally affected. The malady, though common in hot climates, especially in the form of tetanus neonatorum, the navel being infected, is of comparatively rare occurrence in this country, but it is one of special importance inasmuch as study of it has thrown much light upon bacteriological questions. Carle and Rattone first demonstrated that it was an inoculable disease. Nicolaier, in 1884, showed that garden earth, introduced subcutaneously in the mouse or rabbit, was capable of producing typical tetanus; he also described the specific organism though he did not obtain it in pure culture. Kitasato later isolated the anaerobic tetanus bacillus, a sporing organism.

Tetanus almost always follows on a wound which may be very trivial; in idiopathic tetanus the organism gains access to the body through an inflamed mucous membrane. The usual habitat of the tetanus bacillus is the intestinal tract of herbivora, especially the horse; the bacillus has also been found in the human intestine. The soil is polluted with dung and human fæces, contamination of wounds with dirt derived from the soil is liable to set up the disease.

Multiple infection of wounds with organisms such as vibrion septique and pyogenic organisms assist in producing anaerobic conditions and not only permit any tetanus spores present to germinate but encourage the growth of the bacillus and the production of toxin.

Experience in the War has confirmed the value of tetanus antitoxin as a prophylactic; to be of service it must be administered as early as possible and certainly before the onset of symptoms of tetanus.

Trench Fever was one of the most widespread diseases among the troops in the late War. The disease has an abrupt onset, a febrile period of five days or so is often followed by one or more relapses; cutaneous hyperæsthesia over the shins, fibula and ulna is observed. Death practically never occurs, but after effects such as neurasthenia, irritable heart and myalgia are often observed. The organism generally held responsible is Rickettsia quintana, minute bodies probably protozoal in nature, found outside the cells of the alimentary tract of the louse. The malady is contracted both by the bite of a louse and through contamination of an abrasion of the skin (such as the excoriations produced by scratching in scabies) with the fæces of infected lice. The fæces are only infective after five days at least from the time of feeding on patients with trench fever; as late as the eleventh week of the disease the blood of a patient during a febrile attack was capable of infecting lice.

The infective agent is not transmitted by infected lice to their offspring. That the proportion of naturally immune persons is very small is shown by the regularity with which the disease was produced in men of various ages by infected lice. In the experimentally produced cases of the American Red Cross Commission, the incubation period varied from five to thirty days.

The virus is present in the urine of trench fever patients, and sometimes in the sputum. No constant or reliable laboratory test is available for diagnosis. The disease has rarely spread in this country; the cases reported have practically been all recurrences of previous attacks suffered whilst on military service. In one instance a soldier's wife appears to have contracted the disease from her husband about a fortnight after his return from service abroad, after suffering from a recent attack of trench fever.

From experiments it has been shown that relapsing cases can transmit infection.

Trypanosomiasis (*Sleeping Sickness: African Lethargy*)—This disease occurs in tropical West Africa, particularly on the Lower Congo, but also in the basins of the Niger and Senegal rivers. In 1900 its presence was noted in Uganda.

In 1903 Bruce and Nabarro stated that the disease was spread by a tsetse fly (*Glossina palpalis*), in which the development of the trypanosome has been followed; the fly does not become infective until after about twenty days. A more virulent form of trypanosomiasis has been found in Rhodesia transmitted by *Glossina morsitans.*

In 1902 Castellani found trypanosomes in the blood and in 1903 in cerebrospinal fluid from sleeping sickness patients (*Trypanosoma gambiense*). The distribution of a tsetse fly (*Glossina palpalis*) was later found to correspond with the disease.

The period of incubation in the usual form of trypanosomiasis is about ten days to three weeks. In the early stage of trypanosome fever, an irregular fever occurs with a rapid pulse rate, trypanosomes may be present in the peripheral blood. Later the lymphatic glands enlarge, particularly the glands of the posterior cervical triangle (Winterbottom's sign); on puncture of these, trypanosomes are more frequently found than in the blood; in Europeans an erythmatous rash appears. After a latent period varying from several months to several years, in the large majority of sufferers the cerebro-spinal fluid is invaded and the sleeping sickness stage follows. A fine tremor of the tongue appears, the patient becomes apathetic and lethargic and, within a year or at most two of invasion of the spinal canal, dies from coma or weakness or a terminal pneumonia or dysentery. There is very little hope of cure if the disease has gone on to the sleeping sickness stage. Infected tsetse flies have been found a year or more after a district has been depopulated to eradicate the disease, probably the trypanosome has some other host as well as man.

Many domestic and wild animals, also fish, are also infected with trypanosomes; some of these trypanosomes are undoubtedly harmless. It is possible, however, that some of these animals act as reservoirs for infection which is passed on by the tsetse fly to humans.

Prevention is extremely difficult except under conditions of comparative isolation. In the island of Principe the disease was practically stamped out by a campaign against the tsetse fly.

Typhoid Fever—This disease has probably prevailed from very early times. The accounts given of "fever" in the seventeenth century suggest that in some instances the illness described is what is now known as typhoid fever, and it becomes increasingly clear, as regards the eighteenth and the early part of the nineteenth century, that such an inference should be drawn. In the period last named the intestinal lesions were described by Bretonneau, Louis, and others, but there was still confusion as between typhoid fever and typhus. Ultimately, towards the close of the first half of the nineteenth century, the distinction between these two maladies was established, owing to the researches of a number of observers, and especially of Stewart and Jenner.

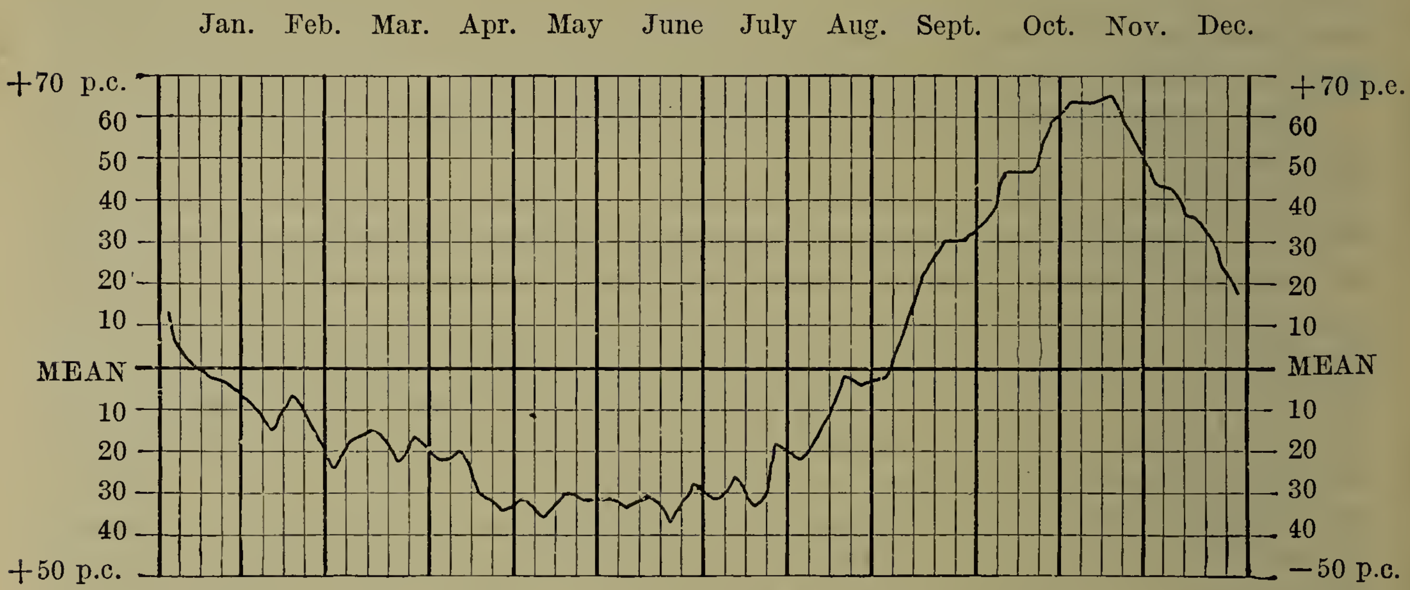

Fig. 83.—Enteric Fever in London (thirty years, 1871–1900).
The mean line represents an average weekly number of fourteen deaths.
(*After Shirley Murphy.*)

The deaths from typhoid fever have, however, only been separately recorded by the Registrar-General since 1869. In the earlier years of registration the death-rate, as a rule, was not far short of 400 per million living, but as time went on, fairly steady diminution was noticeable, in 1911 the death-rate was 67 per million, declining to 26 per million in 1918. The number of notifications has declined of late years from 13,852 in 1911 to 2,414 in 1922. Typhoid fever is a widely distributed disease, but the Tropics appear to be comparatively free from it.

Its prevalence in this country was formerly markedly influenced by season: the autumnal rise indicated by the above figure was until some ten or so years ago a general phenomenon, but in large cities such as London and Manchester it no longer occurs.

The case mortality, as shown by hospital statistics, is about 15 per cent. in persons over 15 years old; in children from one year to fifteen the mortality is in the region of 5 per cent.

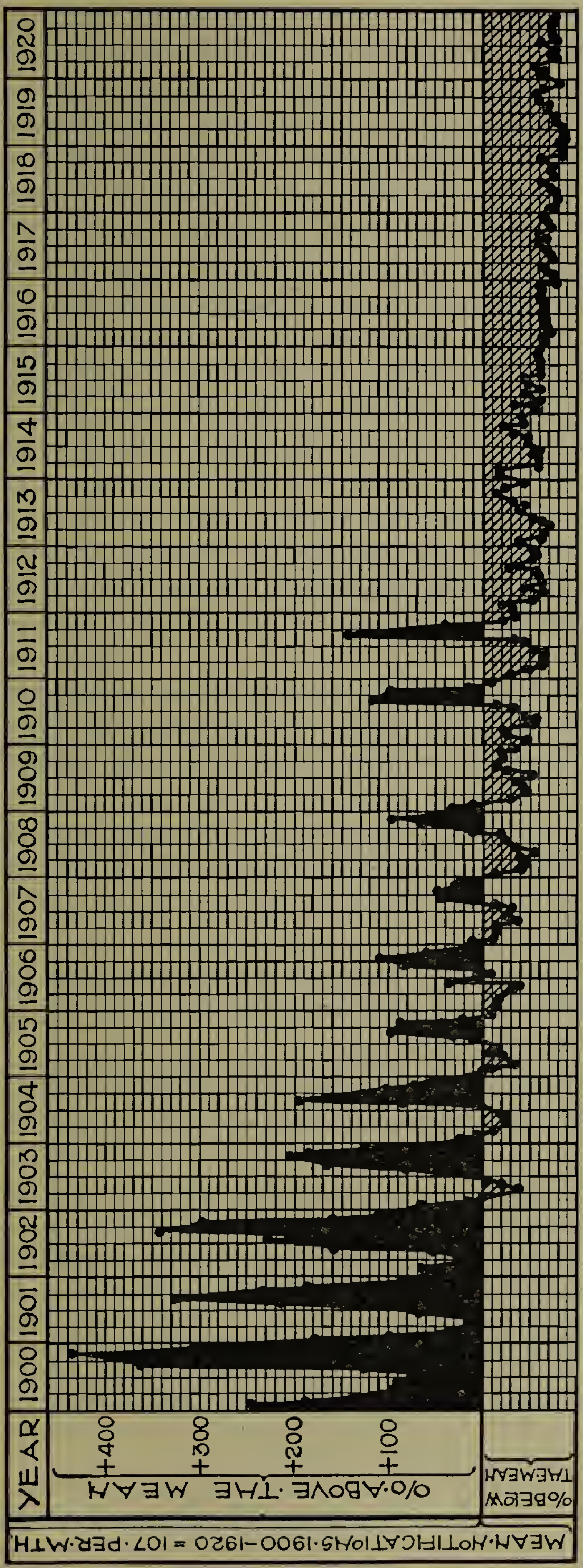

FIG. 84.—Cases of Typhoid Fever notified in London, 1900–1920.

Race, *per se*, seems to exercise little or no influence on liability to typhoid fever. As regards sex, males, between 5 and 20 years of age, are somewhat more frequently attacked than females, but at these ages the *mortality* among females is rather higher than among males. The disease mainly affects the ages 10–25 and particularly the age-period 15–20. In outbreaks of typhoid fever due to water, fish and other articles of food, deviation from the age-incidence observed in typhoid fever attacks as a whole may be noted. It seems probable that fatigue and overwork predispose to the disease ; nurses who are not up to the mark should be removed from exposure.

Since 1897 the introduction of Widal's agglutination reaction greatly facilitated the diagnosis of the disease. The reaction may appear in the first week or may be delayed till the end of the third week. During the first ten days of the illness the organism can be cultivated from the patient's blood ; this procedure is of especial value in patients recently vaccinated against typhoid fever or in those who have had a previous attack ; in such persons a rising agglutination titre during the course of the disease also gives valuable information.

The period of incubation is generally about a fortnight, but it may range from two to forty days ; for purposes of routine inquiries as to causation a period of three weeks is usually taken into account. Second attacks of typhoid fever have been held to occur, but this is very doubtful ; relapses, however, are of common occurrence.

The bacillus first discovered by Eberth, and afterwards studied by Gaffky, is almost always found in the mesenteric glands and in the spleen.

Animals in the natural state do not suffer from typhoid fever : certain pathogenic effects have been produced in rabbits and chimpanzees by artificial means.

Knowledge concerning the spread of typhoid fever by means of polluted *water* is based upon the experience of a considerable number of years.

> "Typhoid outbreaks have been traced to pollution of *shallow wells*, as at Guildford in 1867, in the Uxbridge Rural District in 1882, at Hitchin in 1883, at Beverley in 1884, and so on ; others have been due to pollution of *deep wells*, as at Caterham in 1879 or at Worthing in 1893 (1,315 cases). Other outbreaks have been due to pollution at the *spring*, as at Maidstone in 1897 (1,847 cases) ; or pollution of *streams and rivers*, as in the Tees Valley in 1890, at King's Lynn in 1892, at Lincoln in 1905 (900 cases) ; or, again, contamination of the *ground water*, as at Munich, at Terling, in Essex, in 1867, and at various places in America ; or, once more, to pollution of *water in the mains*, as in the famous case of Caius College, Cambridge, in 1873." [1]

In 1867 Buchanan reported on an outbreak at Guildford, in which some 500 persons were attacked. He showed that this outbreak was due to conamination of the high-level section of the water-supply of the town, by a leaky sewer running within 10 ft. of a deep well sunk in the chalk, from which that supply was derived.

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[1] Newman, "An Outline of the Practice of Preventive Medicine," p. 60.

Two outbreaks which illustrate the risk attendant, under certain conditions, on the intermittent method of supply may be mentioned. In 1874 Blaxall reported on typhoid fever at Sherborne, confined to a small group of houses obtaining water from a particular source. The water supply to these houses had on several occasions been shut off. In some instances the water was directly laid on to the closet-pans by pipes with taps, and a few of these taps were broken. As Blaxall said: "If a pan happened to be full of excrement, that excrement would be sucked into the water-pipe." Again an outbreak of typhoid fever occurred at about the same time among residents in a particular court at Caius College, Cambridge. Buchanan found that the water-closets in this court were supplied directly from the main, without disconnecting cisterns; opportunity for pollution of the water in the supply pipe was, moreover, afforded by a "weeping pipe," which established communication between the supply pipe and a trap connected with the drain. The end of one of the "weeping pipes" was stained with matter of fæcal origin. About a fortnight before the typhoid fever occurred the water supply to the court had been cut off, and probably, in connection with this intermission of supply, specifically tainted material had obtained access to the mains, and had been subsequently distributed to the residents in the court.

In 1879 an outbreak of typhoid fever at Redhill and Caterham, in which some 370 cases occurred, was investigated by Thorne, who discovered that a workman, who had been engaged in excavating an adit between two of the deep wells of the Caterham Company, had suffered from typhoid fever, and had been attacked by diarrhœa on more than one occasion while working in the well.

The small amount of polluting material in this case, in comparison with the huge volume (nearly 2,000,000 gallons) of water infected, was the subject of much comment at the time. Buchanan, in 1881, estimated that not so much as one grain of excremental matter per gallon could have been present.

In 1888 an outbreak at Mountain Ash was found to be caused by pollution of a particular water-main which was defective; the supply of water was intermittent, and the main became contaminated by reason of the fact that it was leaky.

In many of the earlier outbreaks wells had been found to be at fault, and it was thought the comparative freedom from movement of the water in the well, and the fact that it was kept in the dark, might have favoured the multiplication of disease germs. Within comparatively recent years, however, instances of communication of typhoid fever by river water have attracted a considerable share of attention.

In an outbreak at Bangor, in 1882, Barry showed that the water supply derived from a small stream had caused the mischief; this water was nominally filtered, but the operation was only imperfectly carried out, and the water consumed was practically unfiltered water. An outbreak occurred at about the same date at Hitchin, and in this instance it was found, by Power, that a waste pipe occasionally admitted water from the river Hiz into the water-supply tank; the said river, which, however, is "hardly more than a ditch," was grossly polluted with sewage. Other outbreaks, in which river water was suspected to have spread the disease, were those at Gainsborough, Newark, and King's Lynn, reported on by Bruce Low, and that at Farncombe, which was attributed by Jacob to water obtained from the Wey.

Two prevalences of typhoid fever which occurred at the end of 1890 and the beginning of 1891 in certain areas near the mouth of the Tees, and which were investigated in great detail by Barry, constitute, however, the most striking and important of the instances in which dissemination of typhoid fever on a large scale has been attributed to river water. Two outbursts of fever, as has been said, occurred; the first was especially marked during the six weeks ending October 18th, 1890; the second during the six weeks ending February 7th, 1891. In the two outbreaks 1,463 individuals were found to have been attacked. Within the area of the fever prevalence some 219,000 persons were obtaining water from the river Tees, while some 284,000 were deriving their supply from other sources. The attack rates per 10,000 persons during the first outburst were ascertained to be thirty-three, in the case of the persons drinking Tees water, and three in that of the persons drinking other water. During the second outburst, the attack rates were twenty-eight per 10,000 among persons drinking Tees water, and only one per 10,000 among persons drinking other water.

Among outbursts of typhoid fever due to water supply in more recent years the following may be mentioned: In 1893 a large outbreak of typhoid fever occurred in the neighbourhood of Worthing, in which upwards of 1,400 attacks were developed. At Maidstone in 1897 an outbreak, affecting upwards of 1,800 persons, occurred as result of contamination of the Farleigh springs of the Maidstone Water Company.[1]

Since then outbreaks due to infected water have been reported and water-borne typhoid is still a real danger in this country.

The study of a water-borne outbreak of typhoid fever in the Dearne valley of the West Riding which lasted from the middle of July to the end of December, 1921, and caused nearly 400 cases of the disease, is very instructive in that it exemplifies the difficulties attached to the chlorination of water during epidemics.

The first outbreak affected a population of 20,000 persons in the urban districts of Bolton-upon-Dearne and to a slight extent in three rural parishes; this outbreak was caused by infected water from the Dearne Valley Colliery (public) water supply; the only factor common to the persons attacked was that these persons had habitually consumed this water and it appeared likely, therefore, that specific pollution of the water had taken place at its source and not in the course of its distribution; the second part of the outbreak (October 8th onwards) affected the village of Bolton-upon-Dearne, and was caused by infected water from a well in the village. The village shared in both outbreaks; some cases were caused by the infected public supply, a larger number were due to the consumption of the well-water. Of a population of some 3,500 at least 260 suffered from typhoid fever; there were altogether 45 deaths. The subsoil of the gathering ground of both the public supply and of the village wells, consisting of sandstone, was extensively fissured during the hot dry weather of June, 1921. The pollution was probably from the surface as regards the colliery water, a considerable amount of excreta was observed in a wood between April and July, 1921, where the sandstone with many cracks and fissures came to the surface.

In the second outbreak, possible multiple sources of infection of the water supply existed. In an adjacent quarry with large fissures human excrement was seen; it was used as a playground by a child who after recovery may have infected the surface of the ground or this may have been done by other enteric fever cases from soakage from privy middens infected by fæces from the first outbreak. Possibly a shower of rain carried down polluting material from the surface to lower levels.

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[1] Ernest Hart in 1897 prepared a summary of the facts relating to 206 outbreaks of "water-borne typhoid" which had been reported on in Great Britain and Ireland during the thirty-one years, 1863–93.

On September 14th W. V. Shaw ascertained that the public water-supply was being chlorinated, two ounces of bleaching powder were being added (but apparently with insufficient mixing) to every 10,000 gallons of water. The water was clear; it had a low oxygen-absorbed figure, and was free from other than normal traces of readily changeable organic matter. Shaw suggested that *one pound* weight of bleaching powder should be added to each 10,000 gallons of water. If the bleaching powder contained 33 per cent. of available chlorine, the concentration advised was about 3⅓ parts per million gallons of water.

This treatment was recommended as an emergency measure and was carried out for one week. The amount of bleaching powder was however reduced, apparently by the water-works authorities, until before long they were using the original quantity—two ounces in ten thousand gallons. One of the reasons given to Shaw for the continual reduction in the amount of bleaching powder was the complaints from many consumers that the water was made so unpalatable by chlorination that no one could drink it. His own inquiries made locally did not elicit information in support of this complaint.

The second outbreak affecting the village commenced on October 8th with two cases; 17 occurred in the next week and 50 in each of the next three succeeding weeks. Part of the village could not rely upon a continuous service from the public water-supply; it often failed and was cut off entirely on September 27th and again on October 3rd. Shaw goes on to say, "Further, certain people after reading the posters put up in August which warned the public to boil the water were prejudiced against the piped supply, and when it was known that this supply had been chlorinated alleged that it was quite undrinkable." A new water main was laid to the village and supplied chlorinated water. The public wells were closed, one abolished and the owners of two private wells warned only to allow the waters to be consumed by animals; this action was followed by the rapid cessation of primary cases in the village.

The addition of the large amount of chlorine was subsequently criticised, it being held that one part of chlorine in one to five million gallons is enough to sterilise a water that is organically fairly clean and that any excess over this amount will act on vegetable and organic matters in mains and cisterns. But Houston considered that the large dose used was justified: that during the early stages of the treatment in a water-borne epidemic it is desirable to carry to the very mouth of the consumer a liquid in which sterilisation was actively proceeding so as to ensure that the water throughout the whole distributing system, including the cisterns, is absolutely safe. He thought that in this epidemic there may have been occasional flushes of impure water (perhaps responsible for the epidemic) which necessitated the use of large doses of chlorine.[1]

In certain outbreaks the presence of typhoid bacilli in water has been reported, but the question of dosage must be considered. In his Tenth Report on Research Work (1913) Houston gave a full account of attempts to isolate typhoid bacilli from raw Thames water. He obtained two apparently positive results, but he concludes that it is unlikely a single typhoid bacillus can infect a susceptible individual, and he adds "if as seems probable, a number are always or usually required to start the infective process, and they are present as ‘ individuals ’ and not always in ‘ clumps ’ and are equally distributed throughout the filtered water, infection might seldom if ever take place.”

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[1] Small doses (not large) give rise to the "iodoform" taste; the chlorinous taste produced by the larger doses is usually tolerated by consumers better than "the iodoform" taste.

Infected milk and milk products have given rise to outbreaks of typhoid fever.

Trask, up to about 1909, compiled a list of 317 outbreaks, of which 179 were collected by himself and 138 previously by Hart and by Busey and Kober.

In Hart and Busey and Kober’s series, in 109 instances there is evidence of the disease having prevailed at the farm or dairy. In 54 epidemics the poison reached the milk by soakage of the germs into the well water with which the utensils were washed and in 13 of these instances the intentional dilution with polluted water was admitted. In 6 outbreaks the infection was attributed to the cows drinking or wading in sewage-polluted water. In 3 epidemics the infection was spread in ice-cream prepared in infected premises. In 21 instances the dairy employees also acted as nurses. In 6 outbreaks the patients, while suffering from a mild attack of typhoid fever, or during the first week or ten days of their illness, continued at work, and those of us who are familiar with the personal habits of the average dairy boy will have no difficulty in surmising the manner of direct digital infection. In one epidemic the milk tins were washed with the same dishcloth used among the fever patients. In one outbreak the disease was attributed to an abscess of the udder, in another to a teat eruption, and in another to a febrile disorder in the cows. Four outbreaks were traced to creameries. In one epidemic the milk had been kept in the sick-room.

In some of the outbreaks included in Hart’s summary no possible source of contamination of the milk was detected ; possibly had they occurred nowadays some of these might have been explained on the “ carrier ” hypothesis, *i.e.*, a person who handled the milk either during milking or in the dairy or shop or in the home. Probably much the same modes of infection are still taking place ; in an outbreak at Tumble in 1917, the vessels containing the milk had been infected by polluted surface water in which they had been cooled.

The infection was derived from excretal matter thrown on the yard surface derived from those persons who in all probability died from typhoid fever.

Recently made cream even when added to coffee, butter and buttermilk are occasionally media of communication of typhoid infection. The theoretical possibility of transmission by fresh cream cheeses cannot be ruled out, but in hard cheese the processes gone through and the time required for ripening make this source very unlikely.

In one instance reported upon by Geo. Turner, who investigated the circumstances in South-East London in 1891, ice-cream was found to be at fault; it may be that in this case infective property was imparted to the ice-cream by milk, but it is also possible that the infection was directly communicated to the ice-cream, and was not derived from milk.

In 1897 an outbreak of 27 cases was traced to this cause and in 1902 in Finsbury an outbreak of 18 cases; more recently in Hendon in 1917, 17 cases of typhoid fever were traced to infected ice-cream, presumably contaminated by a "carrier." It has been proved experimentally that the process of freezing does not destroy all typhoid bacilli present; repeated thawing and re-freezing gradually has this effect, probably owing to the bacilli being crushed between the ice crystals.

In connection with an inquiry at Eagley and Bolton, in 1876, made by Power, question was at first raised as to the possibility of the milk having obtained its infective properties owing to the existence of some cow malady. A similar suspicion has been entertained in one or two other outbreaks, and Allan of Pietermaritzburg was led, as the result of his experience, to the conclusion that milk may become contaminated in this manner. Klein showed by inoculation experiments, that *Bacillus typhosus* is able to multiply and develop in the lymph glands of the calf. It is, however, not generally believed that typhoid fever is spread by any disease of the cow.

During the latter half of the nineteenth century almost all cases of typhoid fever were attributed to infection from case to case or to infection of water or milk. The causation of the earlier outbreaks needs, however, to be reconsidered in the light of the detailed inquiries, made by Bulstrode and others on the one hand as to the influence exerted in causing spread of typhoid fever by shell-fish and fish, and on the other by Koch and his followers as to the influence of contact and carrier infection.

Bulstrode's report of 1894–5 on oysters in relation to typhoid fever and his later report of 1911 on other shell-fish in this connection have shed much light on the subject and the question of shell-fish origin of typhoid fever has been taken up in other countries, more particularly in America. Bulstrode in 1902 reported on a prevalence of typhoid fever in connection with banquets at Winchester and Southampton and by an exhaustive analysis of all the foods consumed by the different guests at these banquets conclusively demonstrated that oysters were at fault.

Twenty-one cases of typhoid fever and 118 cases of gastroenteritis occurred among 267 guests. At the Winchester outbreak, for example, in some of the patients abdominal pain, vomiting and diarrhœa occurred a few hours after the banquet, in others a similar attack occurred three or four days after; others suffered from typhoid fever and others again suffered from vomiting and diarrhœa shortly after the banquet and also later from typhoid fever.

The oysters were imported from France and stored for a few days in the ponds at Emsworth which occupied "a dangerous position in relation to the [local] sewer outfalls."

A fatal attack of typhoid fever followed the eating of one oyster.

Bulstrode subsequently made an exhaustive inquiry as to the extent to which oyster layings in this country were subject to risk of sewage contamination. The beds are usually situated in the estuary of a river, which bringing down sewage supplies some of the food of the oyster, and often in close proximity to sewage outfalls.

Oysters may become infected where they grow or during the time they are being soaked ("floated") in fresh water to make them plump. Freedom from obvious adjacent sources of pollution can only be determined by topographical survey of the adjoining land, from more remote contamination, *i.e.*, by sewage borne by water from a distance, by bacteriological examination of the water over the layings. The oyster, owing to the filtering action of the gills, contains about ten times as many organisms per c.c. as the overlying water.

In the same volume as Bulstrode's first report [1] were also published Klein's observations upon the viability in sea-water of the typhoid bacillus and of Koch's vibrio, and upon the phenomenon observed when oysters are brought into relation with the organisms named. Briefly stated Klein's conclusions were that both organisms remain viable in sea-water for upwards of a fortnight,[2] "the typhoid bacillus retaining its characteristics unimpaired, whilst the cholera vibrio tends to lose them"; that typical typhoid bacilli were recoverable from oysters which had been kept in sea-water infected with these organisms as late as the seventeenth day, but that Koch's vibrio appeared to undergo definite modification within the shell contents, even more rapidly than had already been found to be the case when this organism was kept in sea-water in which oysters had been placed. Furthermore, in one instance an oyster, obtained from a source exposed to risk of sewage contamination, was found to contain the typhoid bacillus. Since then typhoid bacilli have been recovered on other occasions from oysters.

It is desirable to set up a standard of purity for shell-fish. A more or less suitable standard would be the examination of ten shellfish and the use of $\frac{1}{5}$th c.c. of the liquor from the shellfish [3] or in the case of mussels $\frac{1}{10}$th c.c. The result of the examination may well be stated in the percentage of shell-fish which are found to contain B. coli.

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[1] Report of M.O. of the L.G.B. for 1894–5.

[2] Eyre states that about 2 litres of water enter and leave the shell of the oyster every hour; if this water is clean 7 to 8 days serves to remove pathogenic organisms from the mollusc.

[3] The presence of B. coli in this amount of liquor meant about 200 B. coli in the whole oyster.

The passing or rejection of a sample of shell-fish should be made to depend upon the proportion of oysters or mussels showing the presence of B. coli in these amounts of liquor. Consignments yielding 100 per cent., 80 per cent. and 60 per cent. clean are allowed to be sold without further comment; with 30 per cent. and less clean are condemned forthwith; with 50 per cent. and 40 per cent. clean are held up pending a further analysis and if necessary a revision of the topographical examination of the layings.[1]

Niven has endeavoured to trace the part played by shell-fish and especially mussels in the causation of the disease in Manchester. In 1912 48·4 per cent. of all the patients with typhoid fever had consumed shell-fish, no other explanation of the cause of the disease could be made. Occasionally it was found when two companions ate raw mussels together both contracted typhoid fever. The mussels suspected to be responsible for cases of typhoid fever were traced back to a few out of a number of merchants and eventually it was found that certain layings appeared to exert a far greater influence than others.

In Liverpool cases due to shell-fish are sharply defined by the season of importing mussels from Ireland, viz., October to May.[2]

The consumption of cockles from polluted areas has been followed by typhoid fever. Klein also ("Annual Report of the Medical Officer of the Local Government Board," 1899–1900) made investigations with regard to the extent to which cockles, obtained from areas on the seashore obviously polluted by sewage, retain in their interior living microbes of sewage, and, in particular, as to their ability to harbour living typhoid bacilli.

The Ministry of Health issue regulations from time to time prohibiting the relaying of oysters in certain polluted waters and forbidding the sale of other shell-fish unless steamed under pressure in a suitable apparatus for at least six minutes.

Niven remarks: "It is well known that when put into pure sea water mussels clear themselves of typhoid infection very quickly, say in a fortnight, and this provision will probably suffice if it is kept up and watched."

Hamer considers that in London, at any rate since 1891, flat fish, generally plaice, almost always purchased as cooked (fried) fish and often in an ungutted state, have been responsible for many cases of typhoid fever. The incriminated fish were immature plaice from 4 to 10 inches long brought to London mainly from "fish nurseries" near the mouth of the Elbe.

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[1] See "Public Health and the Oyster," J. W. H. Eyre, "Public Health," Sept., 1924.

[2] Earlier cases of typhoid fever were attributed to polluted mussels in connection with Ramsgate, 1883 (M. K. Robinson); Teignmouth, 1894 (mussels or cockles); River Blyth mussel beds, 1894; Brighton, 1894–5–6.

The gut of these small fish often contains small cockles $\frac{1}{12}$th to $\frac{1}{8}$th inch in diameter; typhoid bacilli enclosed in these cockles may escape destruction on cooking.

In 1906 the London County Council brought to the notice of the City Corporation the special need for the inspection of these small fish at Billingsgate, and since 1907 the fishing-grounds in question have been gradually abandoned by English trawlers. The decline of typhoid fever in London has tallied very closely with the disuse of these grounds as a source of London food-supply.

During recent years it has been found possible by special methods of cultivation to isolate typhoid bacilli from fæces and persons thus affected may continue to be "carriers" of such bacilli for an indefinite period: this has been shown to occur for over 30 years after an attack. Patients continue to discharge typhoid bacilli up to the tenth week of their illness, after that time about 3 per cent. continue to discharge bacilli usually intermittently, their presence in the fæces often coinciding with periods of looseness of the bowels.

The fæces and urine of all typhoid (and paratyphoid) patients should be examined as a matter of routine before discharge and suitable instructions as regards handling of food, etc., should be given to all "carriers" before leaving hospital.

Ledingham's investigation on "carriers" and convalescents from typhoid fever[1] shows that the risk of patients becoming carriers appears to be negligible if their excreta are free from typhoid bacilli on discharge from hospital; such persons may probably be left without further supervision. Typhoid bacilli are, however, found in the stools of persons who are not known to have an attack. Women are more liable to be "carriers" than men; this may be associated with the greater frequency in women of affections of the gall bladder —the habitat *par excellence* of the organism in "carriers."

Fæcal "carriers" are said to be both more frequent and more dangerous than urinary "carriers."

Owing to the intermittency of the discharge of the organisms, it has been suggested that once a person has been proved to be a "carrier," he or she should be advised not to do any work involving the handling of food.

The administration of hexamethylenamin cures typhoid bacilluria; for fæcal "carriers" no remedy exists at present.

It would seem probable that typhoid fever may be spread by dust, especially in camps. Firth and Horrocks, from their experience in the last Boer War, concluded that infected dry soil if blown about as dust is capable of infecting distant objects as long as 24 days after the time of desiccation.

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[1] "Annual Report L.G.B.," 1912–13.

The presence of middens and pail closets in the vicinity of houses thus affords opportunities of contracting typhoid fever, especially in windy and dry weather. Their use in common with other houses encourages careless disposal of fæces in yards and on ash heaps and leads to a filthy condition of the ground about houses readily enabling the contamination of the hands and feet of children. The critical rise in the increase of notifications noticed either in July, August or September follows atmospheric conditions favourable to the production of flies; typhoid stools in middens or pail closets provide abundant opportunities for flies to spread the disease.

The connection between flies and typhoid fever has been closely studied by Graham Smith. He mentions that typhoid bacilli are said to have been isolated from "wild" flies associated with outbreaks of typhoid fever on several occasions.[1]

Evidently the disinfection not only of recently soiled bedding, but of *all* soiled bedding is important. After the South African War some of the blankets and sheets used by the troops were sent to England and although dirty and soiled with fæcal matter were used on a training ship with the result that typhoid fever appeared. Klein recovered living typhoid bacilli from the fæcal stains.

The question of case-to-case infection has been much discussed in recent years. The disease is more likely to occur among those closely associated with the sufferers; for such a mode of infection the term "contact infection" has also been used. Thus persons living in the same house, tent, etc., are more liable to be attacked than others; although infection by articles used by the patient especially comes into play, the mode of spread is the same as in other cases. The first case often may be a child who is thought to be suffering from diarrhœa and no special precautions are taken.

In some hospitals, nurses have not infrequently been attacked; in others the infection of nurses has rarely been observed. The question of age may have played a part in determining these differences. It is notable, moreover, that medical men, as compared with nurses, rarely suffer; it has been sought to explain this as resulting from their being brought into less intimate relation with soiled linen, etc., and further by the greater care exercised by medical men in cleansing their hands after they have examined a patient. The inhalation of the dust from dried fæcal stains scattered when the bedclothes are disturbed may be a mode of infection.

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[1] Apart from definite bacteriological proofs, other evidence clearly points to flies being the carriers of infection in certain outbreaks in which the other principal sources of infection have been carefully excluded. See "Non-blood Sucking Flies in Relation to Disease," G. S. Graham Smith, Chap. XII.

The mortality among nurses has been the principal factor in promoting the treatment of typhoid fever in isolation hospitals and not general hospitals. Experience shows multiple cases in households occur less frequently when a high proportion of the patients are removed to hospital. The absurdity of patients being allowed to remain at home in the absence of skilled nursing is manifest.

Anti-typhoid inoculation has been extensively practised since 1896. Favourable results were in the first instance reported from India, but in South Africa the measure of success obtained appears to have been less complete.

An extensive experimental trial of improved methods of anti-typhoid inoculation, however, was made during the Great War, but as it was accompanied by great care as regards water supply and sanitary conditions generally, it is difficult to evaluate precisely the influence exerted by the several factors in question. In point of fact, there was a great reduction in typhoid prevalence as compared with previous wars. The prevention of typhoid fever has been described as the greatest medical achievement of the War and probably of our time. The following statistical observations would appear to show that inoculation was of considerable value.

Leishman, writing in the Official History of the War ("Medical Services, Pathology," p. 261), says :

> "The case mortality of typhoid is seen (from Table XI on p. 263), which deals with the total number of cases of typhoid, paratyphoid A and B in France from August, 1914, to December, 1918, to be 18·35 per cent. in the non-inoculated ; it is obvious, therefore, that the type of typhoid fever encountered in France was not one of unusual mildness. The contrast is striking to the case mortality among the inoculated, which was only 4·5 per cent."

He goes on to say it will probably be admitted that the experience of inoculation of the armies in France, relating to several millions of men over a period of four and a half years, constitutes a trial on a scale of sufficient magnitude.

The contrast in the mortality rate among the inoculated and uninoculated is not so marked in the paratyphoid A and B fevers.

No. of cases which occurred subsequent to the introduction of T.A.B. vaccine in France on 1st February, 1916.	Cases.	Deaths.	Case mortality per cent.
Paratyphoid A, inoculated with T.A.B. vaccine	463	5	1·08
Paratyphoid B, inoculated with T.A.B. vaccine	894	12	1·34
Total	1,357	17	1·25
Paratyphoid A, not inoculated with T.A.B. vaccine	265	3	1·13
Paratyphoid B, not inoculated with T.A.B. vaccine	858	9	1·04
Total	1,123	12	1·06

In all instances the term "non-inoculated" includes men who had received a single dose of vaccine more than a year before the attack or two doses more than two years before.

Webb Johnson, analysing 2,500 cases of typhoid and paratyphoid infection, showed that these diseases ran a milder course in the inoculated. The mortality of 821 cases of typhoid fever in the inoculated was only 3·28 per cent. as against 19·19 per cent. in 297 uninoculated men; a similar, but not so marked, difference occurred in the paratyphoid fevers. Hæmorrhage took place in 1·21 per cent. of the inoculated and in 13·46 of the uninoculated; as regards perforation, the figures were 0·36 and 2·02 respectively.

All nurses likely to nurse typhoid patients should be inoculated; a multiple vaccine against typhoid and both paratyphoid fevers is preferable. The length of protection given by the inoculation has been variously stated to be six months and two years. Re-inoculation does not cause anaphylaxis. The fear expressed at one time that during an epidemic infection might occur during the negative phase following inoculation has not been proved to be justified.

Paratyphoid Fevers—A variety of infections very closely resembling typhoid fever clinically have of late years been distinguished by bacteriological means.

Chief among these are the paratyphoid fevers A and B; paratyphoid C is now described. Although paratyphoid A and paratyphoid B bacilli present cultural differences, agglutination tests are required in the ultimate differentiation of the two types. Paratyphoid A cases are as a rule less severe in their course than typhoid. Paratyphoid B fever also less severe than typhoid, often shows an abrupt onset; the clinical picture is then similar to that of meat poisoning; pyelitis and broncho-pneumonia may occur as complications

The incubation period of the paratyphoid fevers is stated to be from 9–15 days. Paratyphoid fevers do not protect against typhoid fever and vice versa.

Paratyphoid fevers are found all over the world; outbreaks occur but of limited extent. The disease co-exists with typhoid in endemic foci; cases of paratyphoid A seen in this country are often associated with India, most paratyphoid fever, however, occurring here is caused by the paratyphoid B bacillus.

The etiology of paratyphoid and typhoid fever is almost identical. Vincent and Muratet, however, believe that several domestic animals can act as carriers of the paratyphoid organisms.[1]

Illnesses resembling typhoid fever but running a benign course without complications have been found on the bacteriological examination to be due to infection with the bacillus faecalis alkaligenes; others diagnosed as mild typhoid fever have as the result of blood cultures been found to be due to a coli bacteriæmia.

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[1] "Typhoid and Paratyphoid Fevers" (translated by J. D. Rolleston).

The psittacosis bacillus causes in parrots a septicæmic condition of which enteritis is a prominent symptom; the disease can readily be transferred to man from diseased parrots probably by feathers soiled by excrement; epidemics have been described in Paris and Boulogne-sur-Mer. In man, after an incubation of about ten days, headache, fever and loss of appetite occur, followed by great restlessness, delirium, vomiting and often diarrhœa and albuminuria; frequently broncho-pneumonia supervenes. Death has occurred in about one-third of the cases observed.

Undulant Fever (*Malta or Mediterranean Fever*)—This disease is not confined to the Mediterranean but has been found to occur in India, China, Africa and the Americas, including the West Indies. Cases of fresh infection arising under natural conditions in this country are very rare. Until fairly recently it had not been recognised as a distinct malady, but has been confounded with enteric fever, malaria, etc. The early symptoms are, as a rule, similar to those of the onset of typhoid fever; transitory joint swellings may later be developed; neuralgic manifestations, especially sciatica, are common. The behaviour of the temperature is peculiarly characteristic, a step-like rise of fever occurs for ten or twelve days, followed by a similar fall during the next week or ten days; the temperature remains normal for a few days, to be followed by similar waves; as many as ten have been observed.

Hughes describes a "malignant," an "undulating," and an "intermittent" type of malady. The period of incubation varies from six days to a fortnight; as regards age, children, but not very young children, are found to be specially susceptible. The time of greatest prevalence in Malta has been during the summer months. The fatality does not exceed 2 per cent., but the illness is long, usually lasting three or four months, but occasionally prolonged to a year, and great debility, anæmia, and neuralgia are apt to supervene after an attack.

Bruce, in 1887, isolated an organism, the *Micrococcus melitensis*, from the spleen (an organ which, in fatal cases, is usually found to be soft and swollen). Injection of pure cultures of this organism produced a similar disease in monkeys and the characteristic symptoms in men. The organism can be grown from blood taken at the height of the fever, a valuable method of diagnosis. Considerable reliance in diagnosis is also placed on agglutination methods; the reaction is often manifested about the fifth day, and persists long after recovery, sometimes for more than a year. The facility with which this organism is agglutinated by the sera of patients not suffering with Malta Fever must, however, be borne in mind; by heating the serum to 56° C. for thirty minutes, the non-specific agglutinins can be destroyed.

The demonstration of the micrococcus in goat's milk in Malta throws light upon the ætiology of the disease in man. The Maltese goat is often infected without appearing in any way ill.

The souring of milk does not destroy the micrococcus, spread can therefore be caused by ghee and cheese. Boiling milk prevents infection.[1] The organism is eliminated in the fæces and urine; such urine dried and mixed with dust applied to the glans penis of a monkey caused the disease.

It is thought that sexual intercourse may be a factor in transmission to man; a large proportion of the prostitutes in Malta had the organism present not only in their urine but in vaginal discharges. In any event the urine of ambulant cases must be considered a source of danger and infected dry dust a possible means of transmission. Sheep have recently been found to be infected and the micrococcus may be excreted in their milk; cows, horses, mules, and dogs, are also stated to be liable to natural infection.

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[1] Milk heated up to and above 75° C. is safe; an ortol test exists which in positive cases indicates that the milk has been heated up to this point.

Vaccination with dead cultures confers a certain degree of protection on those exposed to the disease.

Vincent's Angina is usually described as an infection of the faucial and mucous membranes caused by a fusiform bacillus growing in symbiosis with various species of spirochætes. Fusiform bacilli are found in healthy mouths; they may occur in larger numbers in diphtheria. Small outbreaks occur from time to time.

Vincent described two forms of the affection, the less common diphtheroid type with a firm yellowish white false membrane, and superficial ulceration in which fusiform bacilli alone are present, and the ulcerative type with a soft greyish foul-smelling membrane accompanied by ulceration and œdema of the surrounding parts. During the War ulceration of the gums at the root of the teeth accompanied by a purulent discharge was fairly common among soldiers; on microscopical examination fusiform bacilli, together with spirochætes, were found to be present; in a number ulceration of the tonsils resembling the lesion of diphtheria was present as well.

Typhus Fever—It is only since the year 1869 that typhus fever has been separately distinguished in the Registrar-General's returns, but it has probably existed for many centuries, playing its part more particularly during times of war or famine, for prevalence of the malady has been generally found, in later times, to be favoured by conditions of overcrowding and destitution. The "spotted fever" of jails, and some, at any rate, of the recorded outbreaks of "famine fever" and "camp fever," were probably instances of what would now be called typhus, but the likelihood of relapsing fever having prevailed in times of famine, or of enteric fever having devastated camps, must not be lost sight of.

Passing over earlier and more doubtful outbreaks, it is clear that, from the sixteenth century to the early part of the nineteenth, typhus prevailed extensively in Europe. Hirsch gives 1815 as the date of close of this "period of typhus," and states that since then, only once (viz., in 1846–7) did the disease attain, on European soil, "the same general diffusion which the history of pestilence presents to us so often in former centuries." In 1847 the deaths from fever (including enteric and simple and ill-defined fever) in this country exceeded 30,000, a number notably in excess of that in any subsequent year. From 1849–63 the fever deaths never reached 20,000; in each of the years 1864–6 they were, however, somewhat in excess of that number. In 1869, the first year of differentiation of members of the fever group, 4,281 deaths from typhus were recorded, giving a death-rate of 193 per million living; the rate then fell fairly steadily, descending in 1876 below 50 per million living; the fall was slightly checked in 1882–3, but since 1885 it has been less than 10, and since 1907 has been less than 1 per million living.

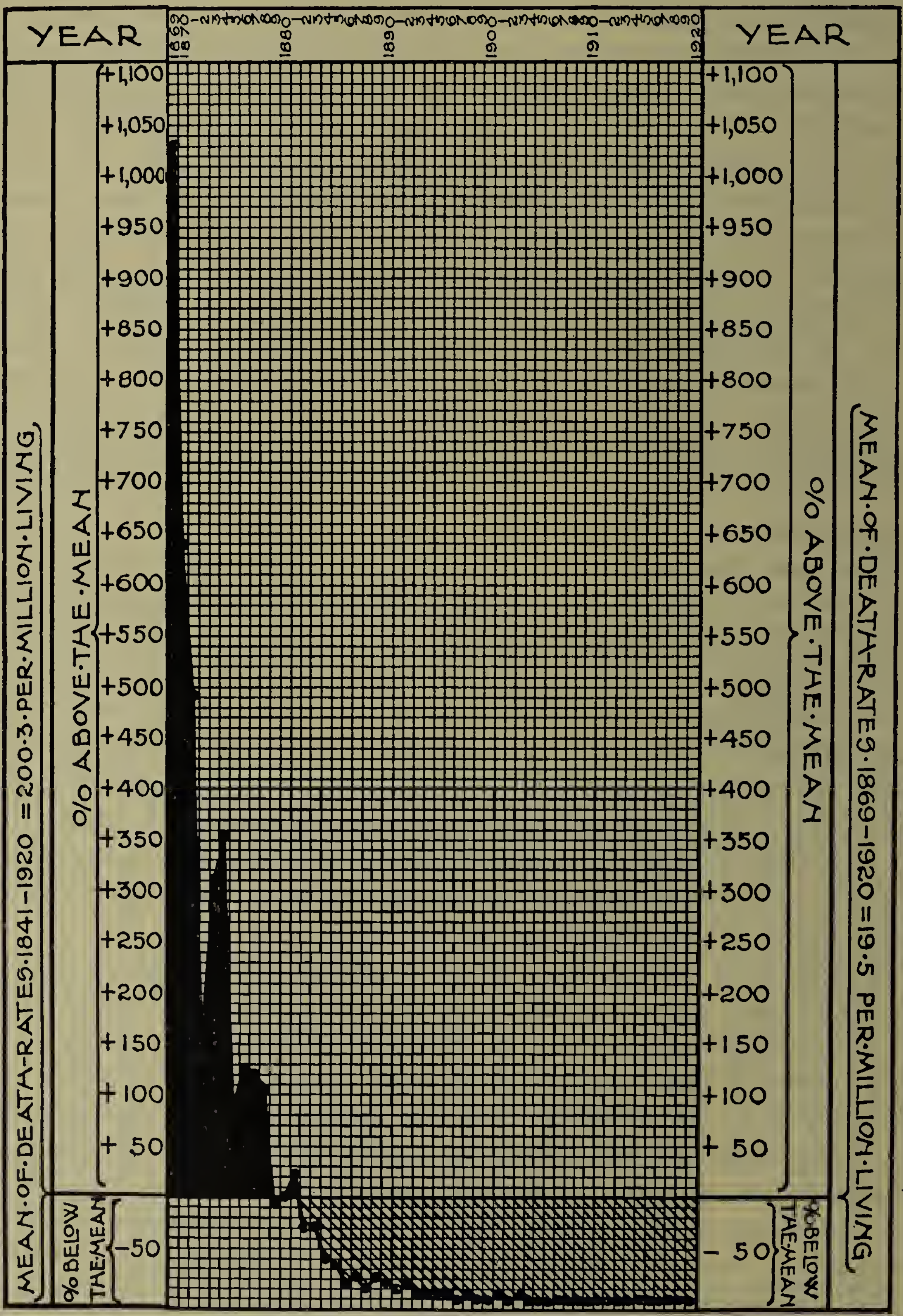

FIG. 85.—Mortality from Typhus, London, 1859–1920.

Ireland has been a particularly favourite seat of the disease in past times; it has occurred within recent years in the Hebrides. During recent years typhus in England has mainly been observed in Liverpool, or in other towns, under circumstances suggesting the possibility of infection having been brought either from Ireland or from Poland and Galicia often by emigrants sailing for America.

Typhus is, in the main, a disease of temperate climates; outside Europe it has prevailed in Persia, North China, Egypt, and North America. It is stated that it has only obtained a footing in the tropics in elevated localities, and at the colder seasons of the year. In this country the disease has shown some preference for the winter and spring months, but it has occurred at all times of the year, in no specially noteworthy relation to season. Typhus attained great prominence in Eastern Europe following upon the Great War.

In the past typhus has been spread largely from towns to country districts by tramps and beggars. Recently, in 1918, a series of cases of infectious sickness occurred amongst gipsies in Surrey and Sussex, all of which were probably cases of typhus. Two gipsies were sent into hospital May 13th and 14th as cases of pneumonia; on tracing their movements it was found that a number of cases of "pneumonia," several of them with rash, had occurred in December, 1917, among gipsies encamped at Eastbourne. Altogether 25 cases of illness were discovered, five of which were fatal. All the contacts with the two cases, some 30 in number, were segregated in their respective camps for nearly three weeks and provided with food by the local Rural District Council. They were then given disinfecting baths and new or disinfected clothing, bedding, etc., and allowed to go their way. On June 19th a child of one of the women patients was admitted to an isolation hospital with typhus fever. The clothing of the infective patient had been thoroughly disinfected by steam: it would seem that she herself must have been still infectious when she rejoined her children. The woman and those in close contact with her were kept under close observation in the Rural District, but no further cases of illness occurred. The points of especial interest are that the outbreak was mainly limited to gipsies and to only a few families of them. Evidently the infectivity of the outbreak was low; this may have been because most of the gipsies were camping in the open under "benders"; the families which suffered most lived in vans.

Children under ten years are less susceptible to typhus than older persons. In children the disease occurs in an abortive form; when a family is attacked, on taking the temperature of the children some, although apparently quite well, show a slight rise: the blood of these patients is infective for monkeys.

The case-mortality in different outbreaks has ranged from 8 to 20 per cent. or more. Children when attacked suffer less than adults; their mortality may be as low as 3 per cent. or even less, but between forty and fifty, fifty and sixty, and over sixty, it exceeds 40, 50 and 60 per cent. respectively. Nothing is known concerning the dissemination of the organisms of typhus by water, milk and food, or its occurrence (apart from laboratory experiments) in the lower animals.

Cold, privations and bodily fatigue appear to predispose to typhus by reducing the powers of resistance. Ordinarily typhus is not directly communicated from man to man; infected human head and body lice have been proved to be the intermediaries in the transmission of the disease. The successful transmission of relapsing fever through lice by Sergeant suggested the experiments of Nicolle, Compte and Conseil of Tunis. They succeeded in passing the infection by means of the body louse from man to monkey and subsequently from monkey to monkey. Later experiments proved that the head louse could transmit the virus, also that it was not until nine to ten days after the lice had been fed on infected monkeys that they and their excreta were infective to other monkeys. Two attempts to reproduce typhus with the offspring of infected (and virulent) lice proved negative.

Delousing measures are now invariably used in the prevention of spread; their success is a complementary proof of these laboratory findings.

The organism Rickettsia prowazeki, considered at present to be more likely than any other to be the cause of the disease, is a minute micro-organism, probably a protozoon, found in pairs and clusters within the cells of the blood of patients and in the epithelial cells of the alimentary canal and in the salivary glands of the louse; it has not yet been cultivated.

The period of incubation is usually twelve days, but Kusama has shown that if monkeys receive the minimum infective dose, the period of incubation will be lengthened and the fever of shorter duration and milder. Contacts in the recent epidemic in Greece were kept under observation for twenty-one days; fifteen days is the more usual period. Murchison considered the disease to be specially infectious from the end of the first week of the illness up to the time of convalescence.

In the absence of head or body lice the disease is only slightly contagious; it is possible that droplet infection may spread the disease especially when pneumonia is present as a complication.

The disease in its epidemic form in the presence of these lice is extremely infectious; the number of doctors and nurses who have contracted the disease and died of it is remarkable. All attendants on the sick should wear louse-proof clothing in the sick-room, and have a bath and a complete change of clothing after the day's work. Outbreaks still occur occasionally on board modern steamships; in sailing vessels on long voyages they were comparatively frequent.

A valuable aid in diagnosis is afforded by the Weil-Felix reaction which owes its origin to the discovery that the X strains of B. proteus, X2 and X19 primarily obtained from typhus urine, are agglutinated by the serum of typhus patients. The minimum dilution to be accepted as positive is 1 in 100.[1] The serum of the vast majority of typhus patients after the eighth day is positive; a negative result is obtained in other diseases. The reaction may appear on the sixth day or be delayed till the tenth; in a few rare cases it is later or does not appear at all (0·36 per cent. of 275 cases).

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[1] See "Journal of the R.A.M.C.," July, 1920.

Relapses are practically unknown, second attacks are extremely uncommon. The blood of typhus patients taken either at the height of the fever or shortly after the crisis and thus containing the living virus has been used for prophylactic purposes; blood inactivated by heating to 56–58° C. for thirty minutes has also been used. It is too early to form an opinion of the value of such prophylactic measures.

Rocky Mountain fever, a specific fever very like typhus, limited to the Western United States, is caused by the bite of the adult wood tick, Dermacentor venustus.

The mortality varies from 5–90 per cent. One attack confers immunity. The tick is found on various domestic and wild animals, especially ground squirrels, woodchucks and chipmunks.

Whooping-Cough—The history of this disease cannot, it appears, be traced further back than the year 1578. It undoubtedly prevailed in England in the seventeenth century. At the present time it is distributed all over the inhabited globe; cold and damp, however, specially favour its prevalence, and the tropics are comparatively free from it. In England and Wales the mortality has ranged, during the years in which registration has been in force, from some 400 to 700 deaths, per million living, annually. The mortality caused by it is thus very considerable; it particularly falls upon the first year of life, at which age-period nearly half the deaths occur, and some 90 per cent. of the total deaths are those of children under five years. Very notable is the comparative immunity of infants in the earlier months from the several infectious diseases. The earliest to declare itself is whooping-cough, which is the assigned cause of some deaths even in the first month, but becomes much more frequent later on, claiming many victims under six months old; next in turn comes measles, but causes no great number of deaths than whooping-cough until the eighth or ninth month is reached, after which it takes many lives; while scarlet fever is still later in its appearance, and scarcely carries off any infants at all in their first year. Shirley Murphy has shown that, as in the case of diphtheria, there has been in more recent decades, when compared with 1861–70, relative increase of incidence of mortality both in measles and whooping-cough on ages 3–4, 4–5, and 5–10. There has also been relative increase of incidence of mortality on the first two years of life in measles and whooping-cough; this is probably attributable to greater opportunity of infection due to increased density of population. Old persons are liable to be affected. Second attacks of whooping-cough are extremely rare. Whooping-cough usually prevails excessively in alternate years; thus in 1917 it was the recorded cause of 4,509 deaths as compared with

9,898 in 1918 ; the number of deaths from whooping-cough in 1919 and 1920 were 2,605 and 4,401 respectively. Beyond this no definite law of epidemic recurrence in the country is apparent on study of annual figures. In Sweden, however, from 1774 onwards, cyclical variations, with an interval between the major prevalences of some four or five years, were manifested.

The case-mortality is about 5 per cent. The seasonal curve shows a maximum mortality in April, and a minimum in September. The period of incubation is two to three weeks ; the disease is infectious from the very commencement, and continues, as a rule, to be so until the characteristic spasmodic cough and the whooping have ceased for at least two weeks, or in cases of persistent whooping until four weeks after the commencement of the spasmodic cough. The bacillus of Bordet and Gengou is generally considered to be the cause of the disease, but this has not yet been conclusively proved ; it is found more readily in the catarrhal stage.

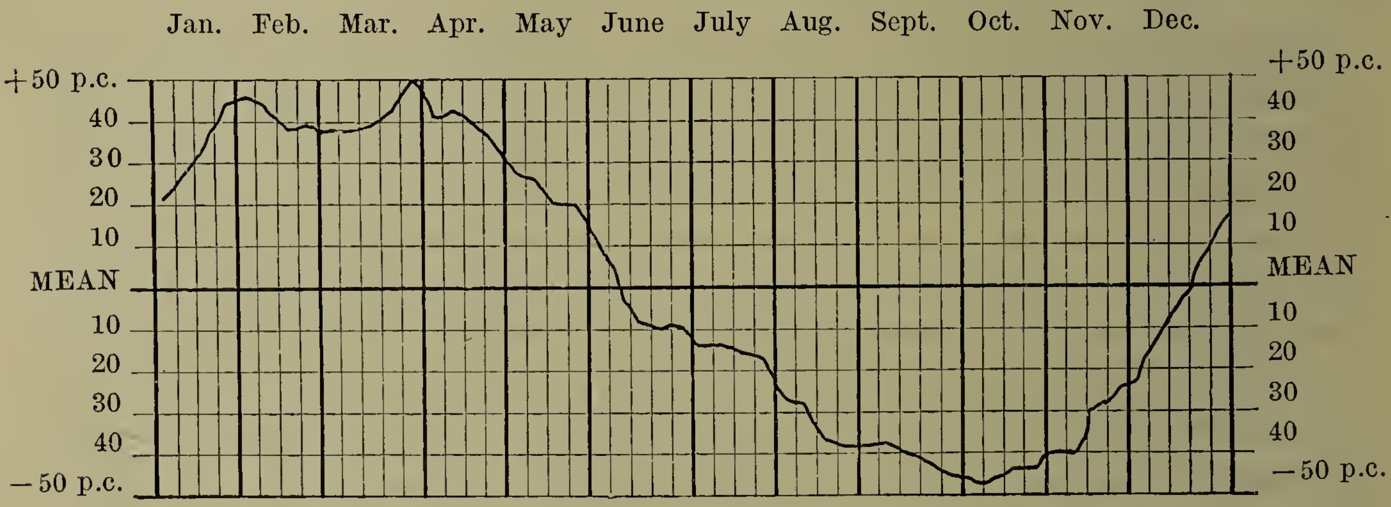

FIG. 86.—Whooping-cough in London (sixty years, 1841–1900).
The mean line represents an average weekly number of forty-six deaths.
(*After Shirley Murphy.*)

The isolation for diagnostic purposes of this bacillus has been attempted, but it is only to be effected by somewhat complicated cultural methods and confirmation is needed by agglutination tests with serum of rabbits or horses immunised against the bacillus. No complement fixation reaction or agglutination test is at present available for practical use in preventive work.

Whooping-cough is highly infectious ; most children suffer from the disease and contract it at their first exposure. There is no evidence that the disease is spread by water, milk, or food, or that it affects any of the lower animals ; the breath is probably the ordinary medium of infection, but all secretions from the mouth and nose and the vomit must be regarded as infective as well as any article contaminated with these secretions. Although the infection is shortlived outside the human body, the clothes of attendant or patients may carry the disease. The disease may be spread in connection with gatherings of children, as for example in schools. Owing to the large number of children attacked before school age, the question of school closure less frequently presents itself in association with whooping-cough than it does, for example, in measles. This peculiarity in the behaviour of whooping-cough is specially noteworthy; it renders particularly difficult the application to it of the preventive measures adopted in the case of other zymotic diseases. Whooping-cough has been scheduled as a notifiable disease in a few instances. Unfortunately very little support is forthcoming in efforts to secure adequate isolation of the sufferers. Admission to isolation hospitals decreases the extent of contact with healthy children and serves as a lesson of the seriousness with which the disease should be regarded. Special efforts should be exercised to detect and isolate the mild cases which often are not presented to a doctor; as a general rule any child with a chronic or paroxysmal cough should be regarded as suffering with whooping-cough if another member in the family is known to be affected with the disease. On medical examination the marked contrast between the severity of the cough and the insignificance of the physical signs is of diagnostic value.

Even if the spread of infection during the paroxysmal stage is slight and if the spread can be controlled in hospitals by efficient disposal of the sputum, two statements which are yet awaiting adequate proof, any relaxation of the usual precautions during the paroxysmal stage would tend to spread the disease among the ordinary population outside institutions and not under skilled supervision.

Respiratory complications, especially broncho-pneumonia, are the chief cause of death. In those who recover a marked deformity of the chest is often seen. With the exception of the measles, no disease is more likely to be a forerunner of tuberculosis. Prophylactic vaccine treatment has up to the present only achieved a very moderate measure of success. Disinfection of the patient's rooms and clothing is advisable.

Yellow Fever—This disease has two endemic centres—the one is Central America with adjoining portions of North and South America, including the West Indies, the other Sierra Leone with adjoining portions of the West Coast of Africa. From these epidemics from time to time extend, but they are notably limited in their power of diffusion by meteorological conditions, as the disease requires for its spread a temperature of over 75° F. Thus from the West Indies the wave of prevalence may proceed northwards to California and to other States, mainly the Southern States of the Union, and may extend as far south as Buenos Ayres. Yellow fever has been imported into Southern Europe, and cases have occurred in Brest, St. Nazaire, and Swansea, but the disease has never really established itself even in Spain. In the neighbourhood of Swansea, in 1865, some twenty cases, fourteen of which were fatal, were developed.

There has been much speculation as to whether Africa, or Mexico and the West Indies constitutes the original home of the disease. The history of yellow fever dates back to 1699 at Vera Cruz, and there is no recorded outbreak in

West Africa until nearly one hundred years later, but the question of priority of claim cannot be pronounced upon with certainty.

The disease is chiefly prevalent at the hot season of the year, and it appears, as a rule, to be favoured by humidity. It affects towns on the coast or on navigable rivers.

The fatality varies in different epidemics—in unacclimatised adults it may be 60 per cent. or more. Males are more often affected than females, and it is especially fatal among the intemperate; probably the excessive consumption of alcohol determines the greater attack- and death-rates in males. The incubation period varies from one to three days.

Numerous records attest the almost universal susceptibility to the disease; one attack usually confers protection. In cities in which the disease is almost constantly present the cases to a large extent occur among strangers; the mortality among permanent residents is comparatively low—under 10 per cent. In New Orleans, during epidemics, children die in large numbers, and this is explained by the fact that, "unlike the children in endemic areas they are not acclimatised." The immunity of residents in endemic areas has been held to be transmitted by heredity; a more probable hypothesis is that it is acquired by undergoing a mild, unrecognised attack of yellow fever.

Sanarelli's Bacillus icteroides is now regarded as a secondary infection. Noguchi has recently cultivated an organism he holds responsible. He names it Leptospira icteroides, and considers it to be intermediate between a protozoon and a bacillus.

Unacclimatised persons who visit yellow fever localities should avoid the poorer and low-lying parts of the town, as filth and overcrowding are said to favour the spread of the disease. Sailors should not be allowed to go on shore. If yellow fever break out on board ship, the best plan is to make with all speed for a region of comparatively low temperature. The United States Army Commission made a number of important observations with regard to yellow fever, in the island of Cuba, during the years 1900 and 1901.

They found that the disease was inoculable, the specific agent being present in the blood during the first three days of the attack. Infectious blood passed through a Berkefeld filter remained infectious, proving that a filterable virus is present.

A special vaccine has been used as a safeguard against infection.

Attempts to convey infection by fomites were uniformly unsuccessful, but a species of mosquito, *Stegomyia fasciatus*, the "tiger" mosquito, if previously fed on yellow fever blood, was, after the lapse of an interval of twelve days or more, found capable of transmitting infection. The adoption of a system of quarantining yellow fever patients in rooms protected with wire screens for the first three days of the illness, so as to exclude mosquitoes from access to them, while at the same time efforts were made to destroy all mosquitoes within a given radius of each case, was attended with marked success.

Stegomyia is essentially a domestic mosquito; it breeds especially in such places as water tubs and tins thrown on to rubbish heaps. Small larvivorous fish have been placed in these water barrels it is thought with success.

Anti-stegomyia measures have been successfully applied to towns such as Habana, Rio de Janeiro, Panama, etc., notorious in the past as centres of diffusion of the disease; not only this but the absence in recent years of European garrisons and fleets from West Indian stations has caused the absence of human beings susceptible to the disease, the native population having been already immunised by a previous attack. The result has been that the incidence in recent years of yellow fever in its endemic areas has considerably diminished.

The fear that steamships would carry infected mosquitoes and yellow fever to other countries has proved vain: on the contrary the substitution of iron steamships with their condensing apparatus for the old wooden sailing ships with their water barrels affording excellent opportunities for the breeding of mosquitoes has proved an advantage. No case has been recorded where yellow fever has been conveyed overseas on a steam vessel to another country unless an actual human case had occurred during the voyage.

VERMINOUS CONDITIONS

Of the vermin affecting the skin in this country the common flea (*Pulex irritans*), the bed bug (*Cimex lectularius*), lice (*Pediculi*), and itch-mite (*Acarus scabiei*), are the most common.

The common flea (*Pulex irritans*) belongs to the class of insects; it has three pairs of legs attached to the thorax and an abdomen made up of segments. It somewhat resembles a fly, but has only rudimentary wings; it possesses a proboscis for piercing and sucking. The female lays a dozen eggs on the floors of rooms, etc.; after six days a worm-like larva is hatched, which in the course of eleven days or so becomes a chrysalis; in another eleven days the fully-developed insect emerges from the chrysalis.

The bed bug (*Cimex lectularius*) is also an insect, but is wingless; it has a mouth in the shape of a beak adapted both for piercing and sucking. The bed bug possesses a characteristic smell, it lives in any dark place, including the wooden frames of bedsteads, emerging at night for its food, and returning to its hiding-place before morning. The adult female during the warmer part of the year lays about fifty eggs. These hatch in five or six days into slender and colourless larvæ, which, after several changes of skin, in ten to eleven weeks are mature and capable of reproduction.

Lice are insects with the thorax very distinctly marked off from the abdomen; their mouths have both piercing and sucking parts.

The head louse (*Pediculus capitis*) is found on the hair of the scalp; it is yellowish brown in colour. The female lays fifty greyish eggs—the nits so commonly seen; they are pear-shaped, fastened at the thin end with chitinous material forming a collar around the hair near the scalp; those more than an inch away from the root are usually empty, the young having been hatched. The eggs are hatched in about a week—the young resemble the adult but are smaller; in about a month they are able to reproduce.

The crab louse (*Pediculus pubis*) is shorter than either of the above forms; it is triangular in shape with the apex behind. The life-history is the same as that of the body louse; the female, however, lays only fifty eggs. The crab louse is found on the shorter hairs of the body, especially those covering the lower parts of the abdomen; the eyelashes are occasionally affected.

The body louse (*Pediculus vestimentorum vel corporis*) is nearly twice as broad as the head louse; it lives in the clothing but feeds on the body. The female lays about 300 eggs in the folds of the clothing; these hatch in about ten to fourteen days; in another fortnight or so the young are able to reproduce. In captivity the life of the adult clothes louse may extend for 46 days, that of the head louse for 38 days. A single female clothes louse can produce 4,000 descendants before she dies.

The body and head louse have been observed to complete the life cycle (from egg to the production of an egg) in 17 days.

If the clothes to which the body lice cleave are exposed at night, when removed to a temperature below 60° F., egg-laying will be restricted or cease altogether.

Well-fed body lice or head lice may exist apart from the human body for upwards of ten days under cool and moist conditions; if kept at body temperature unfed lice die within two or three days at most; any newly hatched larvæ unless they can obtain food die within twenty-four hours.

The itch-mite (*Sarcoptes scabiei vel Acarus scabiei*) belongs to the arachnidæ; it has an oval body, greyish in colour and almost transparent, with four pairs of legs, two pairs in front and two behind. The female burrows into the skin, especially in that part between the roots of the fingers; the skin of the feet and ankles is often affected. The burrows show as small wavy lines of about $\frac{1}{10}$th inch long ending in a blackish speck (the female insect).

About fifteen eggs are laid by each female at the bottom of the burrow; they hatch in about six days into larvæ, which become free by piercing the roof of the burrow; legs are acquired later and the adult form assumed. The male form is smaller and more agile, it excavates the skin just enough to find a lodging and forms a very small brown speck. The characteristic symptom of the disease, itching, usually noticed when in bed, is due to the fluid secreted by the female during the night only. The intense itching causes the patient to scratch, and the scratch marks are often infected. The disease is kept up in the same patient by reinfection from the underclothes and bed linen. Contagion takes place when persons sleep with others affected with the disease; infected bed linen and the handling, washing, and especially wearing of infected articles of clothing account for other cases.

Rooms infested with bed-bugs should be fumigated with sulphur dioxide, the architraves and the skirting boards having first been loosened; the flame of a painter's blowpipe is often applied to non-flammable surfaces infested. Beds are suitably treated by introducing kerosene oil into all the crevices by small brushes or feathers or syringes.

Fleas are similarly killed by the use of sulphur dioxide, but any eggs present escape destruction. Hydrocyanic acid gas kills both eggs and fleas.

Lice depend for their continuation on a low standard of life. Any infestation with body lice will be speedily reduced, if clothes worn during the day are changed at night for clean night clothes and clean underclothing worn and changed weekly. When in addition the bedding is regularly changed, aired, and cleansed and the beds are not crowded together, body lice must die out.

Garments can be freed from body lice by placing them in cold water and heating the water until it is too hot to be borne by the hand. Large articles such as pillows, blankets and mattresses must be sent to a disinfecting station or stored without use for three weeks, a period long enough both to starve the lice and destroy the nits.

To prevent pediculosis of the head girls should be encouraged to wear their hair plaited in order to prevent contact with the hair of another girl. Boys, especially infant boys, should wear their hair short; they should brush the hair at least once daily. School children should have separate and numbered hat pegs to ensure that they take their own cap or hat. The pegs should be sufficiently wide apart to prevent any unnecessary contact of the head-gear.

The plan adopted in the London schools for cleansing the heads of verminous children may be described as follows:—

After discussion of the problem with the late Mr. A. Bacot, laboratory experiments with various mixtures were carried out and the actual operation of cleansing was studied in a cleansing station. A mixture containing wood tar oil as its active ingredient, diluted with paraffin and scented with lemon grass oil to mask the odour of the paraffin, was found to be effective, and not unpleasant. Later a suitable proportion of cotton-seed oil was added to facilitate the removal of the excess of mixture by shampooing with soap mixture. Experiments on individual hairs, showed that borax was effective in loosening nits from hair, so that they could easily be removed by combing or even by sliding down the hair between the fingers. Determination of the breaking strain of several treated and untreated hairs, showed that borax did not weaken the hair or seriously affect its elasticity.

The tar oil cleansing fluid now in use, and the borax soft soap mixture for the subsequent shampoo are prepared as follows:—

Cleansing Fluid.	
Paraffin oil	74 volumes.
Cotton-seed oil . . .	20 volumes.
Oil of lemon grass .	1 volume.
Tar oil	5 volumes.

Borax Shampoo.	
Soft soap	2 pounds.
Borax	4 ounces.
Water to make up to one gallon.	

A typical cleansing station consists of a small building of two rooms—one for undressing, etc., the other for bathing the children and disinfecting the clothes; the latter is provided with a bath and geyser and a vermin destructor, *i.e.*, a small steam disinfector. The children undress in the larger room in front of a fire and are wrapped in grey blankets. Any verminous condition of the hair receives attention, *e.g.*, combed out with a small tooth comb and paraffin oil mixture well rubbed in; if necessary the hair should be cut off with clippers or scissors. The children are then bathed; in the meantime the clothes are being disinfected by exposure to the action of steam for 20 minutes in the vermin destructor; they are dried in the same time by replacing the steam by hot air. After the bath, the children are dried, given white blankets and set in front of the fire to dry their hair.

A special building is not necessary; most isolation hospitals are able to provide a bathroom with a hot water supply and a room for undressing, etc.; the verminous clothes can be treated in the ordinary steam disinfector.

CHAPTER X

DISINFECTION

IT is necessary to distinguish between deodorants, antiseptics, and disinfectants. Deodorants merely destroy or overpower unpleasant smells. Antiseptics retard the growth of organisms but do not necessarily kill them. The term " disinfectant " should be limited to substances capable of destroying the germs of disease. But here there is the difficulty that it is only in certain instances that the organisms can be isolated and experimented with ; again, the knowledge which is available shows that while some are comparatively readily destroyed, others are much more resistant. The destruction of the most resistant known infective material, *e.g.*, the spores of sporing organisms, such as B. anthracis and B. mesentericus vulgatus, is the test of true disinfection and the only safe guide in the existing state of knowledge. Owing to the various situations in which the infection is found and the varying degrees of resistance to the infecting organism, different agencies can or must be employed. The chief agencies at our disposal are heat in the form of dry heat, steam or boiling water, chemical disinfectants, either solid, liquid or gaseous, and direct sunlight and fresh air. Much can be done in the way of mere mechanical removal, for the purpose of subsequent destruction by fire, of articles of small value and the wall-paper after stripping it from the walls, also by scrubbing and cleansing operations.

Disinfection by Heat

Heat may be most effectually applied by boiling or burning.

Boiling is used for the disinfection of bed linen and clothing made of cotton or linen.

Any stains caused by blood or fæces should be first removed by soaking in cold water, and if necessary by rubbing with soap.

Any linen used by typhoid fever patients, especially if it be soiled with fæces, should be placed in a solution of a chemical disinfectant such as Izal, 1 in 200 or Cyllin, 1 in 300, for an hour. In exceptional cases double this strength should be used.

Articles which are too valuable to burn, or which would be spoiled by immersion in boiling water, must be subjected to the action of heat in special forms of apparatus.

Dry heat is useful when the articles to be disinfected would be spoilt by the action of water or water vapour. Articles made wholly or partly of leather, such as boots and books, come under this heading. They are placed in a chamber which is heated by gas or by steam contained in an outer jacket. A temperature of 110° C., maintained for at least two hours, is necessary.

Most articles that require disinfection, however, are made of materials into which dry heat penetrates so slowly that they are injured by this process.

Experiments made by Koch and his assistants, in 1881, cast great doubt upon the reliability of hot-air disinfection. They ascertained that spore-free bacteria were destroyed on exposure to 212° F. for an hour and a half, but that spores were killed only after remaining three hours in hot air at 284° F. The penetrating power of dry heat was found to be little marked, and in order to secure adequate disinfection in the case of bundles of clothes, pillows, etc., prolonged exposure (three to four hours) to a temperature of 284° F. was necessary, and most of the materials to be disinfected were found to be more or less injured by such exposure. Parsons and Klein in this country conducted similar investigations.

Bedding and blankets are the highest outcomes of the ingenuity of man to check the passage of heat from one side of the object to the other; it is no wonder, therefore, that they should be found difficult of penetration by heat. The experiments of Parsons showed that to procure the penetration by heat of bulky articles of badly conducting material high-pressure steam is the agent *par excellence.*

The terms employed in disinfection are most readily explained by reference to a kettle of boiling water.

At the ordinary atmospheric pressure water boils in a kettle at a temperature of 212° F. or 100° C.; the steam given off from the spout is known to the steam disinfecting world as "current steam," but to engineers generally as "low-pressure" steam. If the lid and spout had been tightly sealed on boiling the water in the kettle the steam generated would have collected under pressure and the temperature become raised;[1] steam so generated under pressure in contact with water is called "saturated steam" or "high-pressure" steam.

Saturated steam containing no water in mechanical suspension is termed "dry saturated steam" as opposed to "wet saturated steam."

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[1] At 5 lbs. pressure steam has a temperature of 109° C. (228° F.).
„ 10 „ „ „ „ „ 116° C. (240° F.).
„ 15 „ „ „ „ „ 121° C. (250° F.).
„ 20 „ „ „ „ „ 126° C. (259° F.).
„ 30 „ „ „ „ „ 135° C. (274° F.).

$$t^\circ\,(\text{F.}) = \frac{1060 + 367 \log \dfrac{\text{Pressure in lbs. per sq. in.}}{14{\cdot}7}}{5 - \log \dfrac{\text{pressure in lbs. per sq. in.}}{14{\cdot}7}}$$

When all the water is converted into steam the contents of the kettle become “ dry steam ” or “ superheated steam,” a hot gas which like the hot air produced by dry heat is of limited use as a disinfecting agent.

The penetrating power of steam heat is due to more than one cause. In the forefront is the large amount of latent heat contained in steam. When the steam derived from one kilogram of water condenses, 537 Calories are given off in the form of latent heat. When this steam comes into contact with cold articles not only does it impart its own heat but much of it condenses ; the latent heat is given off to the articles. Again, the fact that condensation of steam makes way for more steam, has an important influence. When steam penetrates into the interstices of a cold body it undergoes condensation in imparting its latent heat as aforesaid to the body. When condensed into water it occupies only a very small fraction (about $\frac{1}{1300}$) of its former volume. To fill the vacuum thus formed more steam presses forward, in its turn yielding up its heat and becoming condensed, and so on until the whole mass has been penetrated. On the other hand, although hot air, in yielding up its heat, undergoes contraction in volume, the contraction is very slight in comparison with that undergone by steam in condensing into water.

Other influences tending to facilitate the penetrative power of steam, are the fact that heat is evolved in moistening hygroscopic substances ; that the specific heat of steam is greater than that of air ; and that the diffusive power of steam exceeds that of air (the diffusion of two gases into one another taking place with a velocity inversely as the square roots of their respective densities)—all sources of advantage on the side of steam. Finally, steam can be used under pressure, and the effect of intermitting the pressure can be brought into play. Saturated steam, ever ready to condense on coming in contact with an object cooler than itself, constitutes a most efficient penetrating agency ; when under pressure it drives out the air more quickly and penetrates more rapidly and certainly to the interior of bulky articles ; its temperature is higher.

Saturated steam when brought into contact with the walls of a disinfecting chamber and with articles of lower temperature than itself will deposit moisture. A fall of pressure occurs which in older types of apparatus was met by a further supply of steam. In addition the welting of the articles produced by this moisture and the heating gave rise in some instances to shrinking and running of colours and often necessitated their being dried after disinfection. These defects are now met by the provision of a jacket, steam being admitted to the jacket at a higher pressure, *e.g.*, 30 lbs. per square inch (and consequently at a higher temperature) to that in the chamber, *e.g.*, 20 lbs. per square inch.

It is important that the disinfecting agent should be steam only (or steam containing a certain proportion of water) and not a mixture of air and steam. Gruber's experiments among others show that a mixture of air and steam is no better than hot air [1] for the destruction of micro-organisms and rapidity of penetration of the heat to the interior of the articles to be disinfected. This air can be removed by a current of steam, but the process of disinfection is relatively slow. Von Esmarch showed that it took nearly two hours for a current of steam to raise the temperature in the middle of a bundle of articles to 100° C.; spores contained in garden earth were not killed by exposure to moist heat at 100° C. for eighty minutes.[2]

The *steam disinfectors* in common use at the present time are adapted either for the use of steam under pressure or of current steam; again, the steam may be saturated. High-pressure steam (10 to 30 lbs. to the square inch) possesses considerable penetrating power, and the time of exposure necessary is therefore lessened; moreover. the pressure can be raised and lowered, thus greatly favouring penetration. A temperature of 115° to 120° C. can be obtained in high-pressure stoves, and the period of exposure of articles in them can be reduced to fifteen minutes. In some appliances a partial vacuum is produced, by directing a jet of steam across the orifice of an opening communicating with the disinfecting chamber, before steam is admitted to the latter, and by this means the subsequent penetration is greatly facilitated; or, after the disinfection has been effected, a vacuum may be created, and dry hot air then drawn into the chamber, so as to remove any condensed moisture from the disinfected materials, and enable them to be restored to their owners in a dry condition.

In the working of the Manlove Alliott high-pressure steam disinfector the articles to be disinfected are placed in the chamber; steam is admitted to the jacket until the pressure of 30 lbs. to the square inch above atmospheric pressure is reached.

The chamber is exhausted by passing a rapid current of steam under pressure across a small aperture in the bottom of the chamber; this sucks out the air present not only in the chamber but also that present in the interstices of any articles therein. A "vacuum" of 15 to 18 inches is produced, *i.e.*, the pressure is reduced to about half an atmosphere. Steam is admitted to the chamber until a pressure of 20 lbs. to the square inch above atmospheric pressure is attained. The pressure is maintained for 15 minutes; the exhaust is opened, the steam allowed to escape until atmospheric pressure is reached. The vacuum-producing apparatus is then used again, the pressure being similarly reduced to about half an atmosphere.

Air warmed by passing over the steam coils containing hot steam from the jacket of the apparatus is admitted; this rushes in to fill up the vacuum and thus penetrates the articles, at the same time taking up any moisture present; in this way the articles in the disinfecting chamber are not only further heated and thus disinfected but are at the same time dried.

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[1] "Erklarung der Disinfectionskraft des Wasserdampfes" ("Centralbl. f. Bakteriol.," 1888, Bd. III, p. 364).

[2] "Der Henneberg'sche Desinfector" ("Zeitschrift für Hyg.," 1887, Bd. II, p. 342).

By omitting to introduce steam into the disinfecting chamber the apparatus can be used as a hot-air oven heated by steam. The use of the vacuum ensures the rapid penetration of the hot air and the complete disinfection of the articles in a much shorter time than would otherwise be necessary.

In some stoves steam without pressure is used, and here, while the penetration per unit of time is less, the current of steam gradually drives before it the air contained in the materials to be disinfected, and thus secures in the long run more complete penetration than can be obtained with steam confined under pressure, unless adequate provision for escape of the steam from time to time, and for alternations of pressure, be made.

Thresh and others have shown that a rapid current of steam passed through a machine removes the air present, but the first machine which incorporated this principle had the disadvantage of leaving an excessive amount of moisture in bulky articles. Subsequent experiments showed that this difficulty could be overcome by using a chemical solution which raised the boiling-point of the water above the normal. Potassium carbonate is now employed for this purpose and a temperature of 215° F. utilised, thus heating the chamber slightly above the condensing point of steam at atmospheric pressure. To supplement this, hot air is introduced after the passage of the steam. The salt used also prevents incrustation in the jacket of the disinfector. This type of machine is much used in small institutions where the expense of a more complicated apparatus is not desired.

The current of steam is passed for 15 to 30 minutes according to the density of the articles to be disinfected; with bulky articles such as mattresses and pillows the drying process must be continued for 20 to 30 minutes, and the articles then taken out and laid over trestles or a clothes-line to cool and to promote evaporation of the residual moisture.

Reck's stove does not possess the outer jacket. It is a low-pressure stove and comparatively inexpensive, but longer exposure of the materials to be disinfected is necessary. A device employed in this apparatus is the introduction of a cold shower of water, after disinfection, into the chamber (avoiding, of course, the articles it contains), in order to rapidly condense the steam. Air then enters to fill the partial vacuum formed, and drying of the disinfected articles can be thus effected.

The Equifex disinfector has no outer jacket; it can be obtained adapted for either high or low pressure. After air has been driven out of the chamber by the introduction of steam, the pressure of which reaches 10 lbs. per square inch above atmospheric pressure, the complete removal of the air in the pores of the bedding and clothes is effected by releasing the steam from the disinfector every five minutes or so. The sudden reduction of pressure to that of the atmosphere causes the moisture condensed on the articles to evaporate suddenly, *i.e.*, to assume a very large volume (1,300 times its former bulk), and in its escape from the chamber to draw out the air contained in the pores of the articles.

The " Sack " steam disinfector in its simplest form consists of a steam-tight sack which is filled with infected clothing, blankets, etc., and the mouth then partially closed by a draw-string.

This sack is suspended from any convenient point in an inverted position, connection being made by hose from the top of the sack to the boiler, and steam is admitted at slightly over atmospheric pressure. As the steam enters at the top of the sack the air in the sack is gradually expelled through the down-turned mouth of the sack until the whole of the sack and its contents are saturated with live steam, which liberates its latent heat by condensation and sterilises the contents. Experiments have shown that after steam begins to emerge freely from the sack mouth, continuance of the process for five and a half minutes kills anthrax spores protected by eight layers of blankets in fifteen minutes; a temperature of 102° C. is reached near the middle of the sack early on in the disinfection.

Thresh's emergency disinfector consists of an oblong chamber large enough to take an ordinary bed when folded; an oil furnace heats a pan of water used to produce the current steam saturated with the vapour of formalin, the addition of which has been shown to aid the process of disinfection greatly. When the disinfection has been effected a baffle plate can replace the pan of water and the air heated to dry the clothes.

Delépine compared low- and high-pressure current steam disinfectors as follows :—

Low-pressure disinfectors when properly designed are generally sufficient for all practical purposes, and destroy all known pathogenic organisms in from 15 to 30 minutes, according to the bulk of the material and the way in which it is packed. They supply steam which, when wetting is successfully avoided, produces less alteration of the goods than steam at higher temperature. They allow a simpler construction to be adopted, may be made of lighter material, and, therefore, should be less costly. Their lightness makes them specially suitable when portable disinfectors are needed.

Their disadvantages are the possibility that some dangerous organisms yet unknown may possibly escape disinfection by steam at low pressure; this is not possible when steam at 10-lbs. to 20-lbs. pressure is used.

Disinfection by steam at low pressure *is slower* than disinfection by steam at high pressure, as the former penetrates bulky articles more slowly than does steam at high pressure, when the quantity of steam used is the same.

Articles which have been submitted to dry steam at a temperature above 100° C. dry more quickly than articles which have been treated by steam at 100° C.

The advantages and disadvantages of high-pressure disinfectors are sufficiently indicated by the above statements.

High-pressure current steam is certainly preferable to a high-pressure confined steam; the presence of air prevents the rapid penetration of steam and the connection of heat to the centre of articles contained in the disinfecting chamber.

Where neither cost nor weight is prohibitive it is safer to use a high-pressure current steam disinfector.

The modes in which injury to articles by disinfection with heat may occur are:—

1. Scorching or partial decomposition of organic substances by heat. In its incipient stages this manifests itself by changes of colour, changes of texture, and weakening of strength.
2. Overdrying, rendering materials brittle.

These modes of injury were common when dry-heat apparatus was used; with steam they are comparatively unimportant.

3. Fixing of stains, so that they will not wash out. Dyers and calico printers use high-pressure steam for the purpose of fixing their colours; this property of heat is inconvenient from our present point of view.
4. Melting of fusible substances, such as wax and varnish. To prevent this all fusible and inflammable substances should obviously be removed prior to use of the steam disinfecting apparatus.
5. Alterations in colour, gloss, etc., of dyed and finished goods.
6. Shrinkage and felting together of woollen materials.
7. Wetting.

Dry heat is less likely than steam heat to cause injury in the ways indicated under these heads; hence it is still sometimes used for disinfecting books, and articles made of leather, etc., which steam heat would injure, although generally this is supplemented by the action of formalin vapour. Books are often opened so that their pages are subjected as far as practicable to the action of the disinfectant. Articles which cannot be satisfactorily disinfected should be burnt. Injuries caused by "shrinkage," "felting together, and loss of elasticity and fluffiness, upon which the warmth and softness of woollen materials depends," and damage by "wetting," which may produce shrinkage and cause colours to run, cannot be altogether obviated in steam disinfection. The effect is more marked with steam at high pressure than with steam at low pressure, but the quality of the goods is not materially altered by steam under pressures not exceeding 20 lbs. Flannel, and woollen blankets are generally more altered by ordinary washing than by steam disinfection. Wetting during sterilisation is a frequent source of damage, but this does not occur in well-constructed machines.

To prevent disinfected materials being re-contaminated by being brought in contact with infected materials, the disinfecting station is designed in such a way that the room to which the infected goods are brought is aerially disconnected from that from which disinfected goods are removed, the disinfecting apparatus being built into the wall separating the clean and infected portions of the establishment. Again, separate covered conveyances should be used for bringing infected materials to the station and taking disinfected articles back to the homes. Attendants should not pass from one part of the building to the other; and, indeed, every precaution should be taken to prevent intercommunication between the infected and non-infected sides of the premises. In London it is not uncommon to erect on the same site a shelter to accommodate persons "who have been compelled to leave their dwellings for the purpose of enabling such dwellings to be disinfected by the sanitary authority." The duty of making such provision has been imposed on sanitary authorities under Section 60 (4) Public Health (London) Act, 1891. In the country, generally, there is no obligation to make such provision unless the Infectious Diseases (Prevention) Act, 1890, is in force. (See p. 697.)

Chemical Disinfectants

The value of a disinfectant in practice depends not only on its germicidal power but also on its reactions with the extraneous matter accompanying the organisms such as mucus, urine or fæces. Undoubtedly selective action takes place, organisms show different resistances to the same germicide and their relative resistances to two different germicides will not be the same.

One of the most powerful disinfectants is perchloride of mercury; a solution containing one part of this reagent in 1,000 parts of water is able to kill anthrax spores in a few minutes. An important point in connection with the use of perchloride of mercury is that it coagulates albuminous substances, and consequently, when material containing such substances in any quantity is to be disinfected, the perchloride of mercury solution must be added in considerable excess, in order to make up for the waste caused by the coagulation. Its value is also lessened by its being precipitated by a large number of substances including hard water, alkalies, many salts, metals and sulphides. The mercury salts follow the general rule that the germicidal power depends upon the metallic ion and is in proportion to the degree of ionisation, so that a solution of 1 in 500 is far less than twice as active as a solution of 1 in 1,000; also, the chloride is four times as active as the cyanide, a salt which in solution is only slightly dissociated into its ions. The germicidal action seems to depend upon the reaction which takes place between the mercury and the protein of the organism. Perchloride of mercury is a very powerful poison and caution must be exercised in its use. The solution may with advantage be coloured in order to prevent any possibility of mistake; the following formula is often employed: Mercuric chloride, ½ oz.; hydrochloric acid, 1 oz.; aniline blue, 5 grains; water, 3 gallons.

Mercuric iodide does not precipitate albumin to the same extent as the chloride; it is also less poisonous.

The phenols and cresols are obtained from the distillation of tar. Pure phenol (carbolic acid) has the formula C_6H_6O. Cresol or cresylic acid is methyl-phenol, C_7H_8O. Ordinary commercial carbolic acid is in the main a mixture of ortho-, meta-, and para-cresols. Cresol is found to possess a slightly greater disinfecting property than pure phenol. The most important germicides derived from coal tar are those containing "tar acids." They may be classed as those containing (1) cresols with sodium or potassium salts of fatty acids, (2) creosote oils with "low boiling" tar acids and soap, (3) creosote oils with "high boiling" tar acids and soap, (4) "high boiling" tar acids emulsified with soap and gelatin or casein or dextrin or gum.

About 25 per cent. of "low boiling" tar acids, chiefly phenol and cresols, are found in a creosote oil obtained by fractional distillation (200°–300° C.) of a tar derived from the distillation of coal at high temperatures. This creosote oil mixed with soft soap forms a dark coloured solution of soap in oil which when added to water forms an emulsion of oil in water; it constitutes the cheaper type of coal tar disinfectant with a coefficient of 1 to 4.

The "high boiling" tar acids are derived from a tar obtained by distilling coal at low temperatures. By the distillation of this tar a creosote is obtained from which phenol and the cresols can be separated by fractional distillation; the residue, xylenols and tri-methyl phenol, constitute the "high boiling" acids and are used in the manufacture of the more expensive coal tar disinfectants. Owing to their slight solubility these tar acids to be effective germicides must be applied in the colloid state. The ordinary coal tar disinfectant consists of a solution of soap, creosote oil, tar acids and a small quantity of water. On diluting the disinfectant with water the soap oil solution is broken up and the oil distributed in the colloidal state throughout the water in a state of very fine division. The small oil globules are prevented from coalescing by the emulsifying agent, soap, which is adsorbed at the surface of each globule. The emulsion will only remain stable as long as the adsorbed soap film remains intact. Hence the ready destruction of the efficiency of these disinfectants by solutions of electrolytes, acids and the chlorides of the alkaline earths. To minimise the action of electrolytes, an emulsified form of phenoloid disinfectant has been produced in which the tar acids are emulsified with soap in the presence of a protective colloid—gelatin, casein or dextrin;

so that at the oil water interface is adsorbed not only a layer of soap but also a layer of the protective colloid.

A coal tar disinfectant such as Liquor Cresolis Saponatus consists of a mixture of "tar acids," creosote oil and castor oil saponified with caustic potash. The soap is dissolved in the oils, and the tar acids in the soap solution. On adding the disinfectant to water, a white emulsion is formed in which the oil mixture is the disperse phase and the soap solution the continuous phase. Owing to adsorption at the interface, soap is concentrated at the interface, forming a strong soap solution around each oil globule with a weaker soap solution as the continuous medium. The strong soap film will take up the soluble constituents of the oil globule in a proportion which depends upon the respective solubility of the tar acids in the soap solution and the creosote oil. Under the microscope the oil globules in a state of fine emulsion, are to be attracted to the organisms, probably owing to the difference in electric charge. The volume of the globules is about $\frac{1}{1000}$ of that of the organism; the smaller the particles the greater is the number that will hit the organism in a given time, treating it with a more or less saturated solution of the germicidal agent. Izal, cyllin, cresol, Jeyes' fluid and lysol are other examples of coal tar disinfectants; lysol, owing to the presence of highly toxic phenols, is very poisonous. A ten per cent. admixture of izal with water has been found capable of destroying anthrax spores in twenty minutes.

Formalin is an aqueous solution of formaldehyde concentrated so as to contain about 40 per cent.; the solution deteriorates, the average content being about 36 per cent. and the quantity used should be increased accordingly. Mercuric chloride solution, formalin and the coal tar disinfectants have been largely employed in the form of spray, a convenient way of applying the agent and one which, owing to the fine division of the liquid, enables the effect to be achieved with the minimum amount of liquid, thus saving expense and the inconvenience of superfluous liquid.

One ounce of mercuric chloride in 1 in 1,000 solution disinfects about 3,000 square feet of surface. Spray producers consist of a chamber to hold the liquid disinfectant which is driven by air under pressure against a nozzle with many fine perforations. By means of a flexible tube the nozzle can be directed against the various surfaces in turn; in experienced hands an ordinary sized room can be sprayed in ten minutes.

Another mechanical means of supplying liquid disinfectants is by the use of brushes. Thus bleaching powder can be used as a wash and the walls, floor and ceiling coated by means of a brush. The use of bleaching powder in this form of a disinfectant, followed by limewash, is prescribed for disinfecting purposes under the Diseases of Animals (Disinfection Order), 1906, in places where animals with glanders or foot and mouth disease have been kept. Chlorinated lime (bleaching powder) when freshly prepared contains 33 per cent. of available chlorine, but readily deteriorates unless kept in air-tight retainers; calcium hypochlorite formed on contact with water is the active germicidal principle, but the nascent oxygen, chlorine and the chloramides formed during the process of disinfection are all powerful germicides. Chloramides or their hydrolysis products are formed by the interaction of the hypochlorite with animal protein. Bleaching powder is a useful agent for disinfecting excreta, but it destroys fabrics and metals; as it deposits about 40 per cent. of lime it is unsuitable for use in connection with drains.

Chlorinated soda, chloros, hermite fluid and Dakin's solution depend for their efficacy on the presence of hypochlorites. Antiformin, a mixture of equal parts of liquor sodæ chlorinatæ and a 15 per cent. solution of caustic soda, is a very active germicide for ordinary bacteria but not for the acid fast bacilli.

Lime requires the addition of water to become a germicide; it deteriorates owing to the absorption of atmospheric carbon dioxide, the inert carbonate being formed. The use of whitewash—slaked lime mixed with water—is a very satisfactory method of destroying non-sporing organisms which may have lodged on walls, etc. Milk of lime—slaked lime mixed with water to the consistency of a thick cream—is useful for the disinfection of fæces. Quicklime has been much used for the rapid destruction of the infection in buried corpses; of late its place for this purpose has been taken by bleaching powder.

Sulphate of copper, iron and zinc and chloride of zinc (which forms the main ingredient of Burnett's fluid) have all been tried as disinfectants, but are not so satisfactory as mercuric chloride, carbolic acid, the coal tar products, lime, the hypochlorites or formalin. Potassium permanganate is much used in India for purifying water in wells, but is of doubtful efficacy; its value is limited by the readiness which with it is reduced by organic matter, the cost of the quantity required to destroy both the contagium and the vehicle bearing it would be excessive. Its germicidal powers are due to the free nascent oxygen which it readily gives up.

Acids such as sulphuric and hydrochloric have strong germicidal powers; acetic, formic and salicylic acids are effective but weaker; boric acid is very feeble.

Alcohol coagulates proteins and thus loses in efficiency as a germicide. The most efficient strength is between 50 and 70 per cent., when it is capable of killing non-sporing bacteria fairly readily.

Soaps alone even in strong solution and with long exposure cannot with certainty destroy typhoid bacilli or cholera vibrios or the micrococci of suppuration. But used as they often are with very hot water which itself has a germicidal value and with the forcible rubbing of surfaces they assist in the removal and possibly in the destruction of some of the infection.

Testing of Liquid Disinfectants—Several methods have been devised to test the germicidal power of disinfectants. Koch in 1892 introduced the thread method,—the germicidal value being measured by the time taken to destroy anthrax spores on threads. Delépine later used threads soaked in cultures of B. coli and B. typhosus, but the same objections hold to the variation as well as to the original method. The last traces of grease from the threads are very difficult to remove; a film of dry albuminous matter from the broth emulsion protects the organisms and dried threads; when testing an emulsified disinfectant it is very difficult to be certain that some of the disinfectant does not remain to exert inhibitory powers, when the thread is cultured or used for inoculating animals.

In 1897 Krönig and Paul used small garnets of uniform size instead of threads.

Rideal and Walker's drop method introduced in 1903, or one of its several modifications is at present widely used.[1] The germicidal value—the carbolic acid coefficient—is stated in multiples of the germicidal power of a corresponding dilution of carbolic acid.

Before commencing the test proper it is necessary to ascertain the dilution required of the carbolic acid control which will produce the effect which has been fixed upon as a standard, *i.e.*, life in a standard culture of typhoid bacilli after 2½ and 5 minutes' exposure and death after 7½, 10, 12½ and 15 minutes' exposure. This is done by making a trial test with 5 dilutions of the carbolic acid only. To test the disinfectant solution five medication tubes are placed in the lower tier of the test-tube stand and kept by a water bath at a temperature of 15° C. to 18° C. Five c.c. of the control solution of carbolic acid are pipetted into the fifth medication tube, the other four receiving 5 c.c. of various dilutions of the disinfectant being tested. The tubes are inoculated with 5 drops of the standard culture and subcultures are made every 2½ minutes up to 15 minutes into tubes of sterilised standard broth and are incubated for at least 48 hours at 37° C. The germicidal power of the disinfectant is calculated by dividing the dilution of the disinfectant which produces the standard result by the dilution of the carbolic acid control.

The method has been criticised on the ground that it does not test the disinfectants under circumstances in which they are used in practice, the organisms under natural conditions being surrounded by the organic matter of mucus, urine, or fæces.

The modification by Martin and Chick attempts to meet this objection. The germicidal value of the disinfectant is tested on a culture of typhoid bacilli in an emulsion of sterilised human fæces;

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[1] See "Journal of State Medicine," Oct., 1923, p. 477, on the need of better defined standards of the materials used in the test and for the declaration of the technique employed.

many of the coal tar disinfectants so tested were found to possess considerably smaller coefficients than when tested by the Rideal-Walker drop method.

Park gives as the comparative germicidal values for the following substances :—

Mercuric iodide	40,000	Zinc chloride	500
Pure formaldehyde	25,000	Carbolic acid	333
Hydrogen peroxide	20,000	Potassium permanganate	300
Mercuric chloride	14,300	Ferrous sulphate	200
Silver nitrate	12,500	Boric acid	143
Formalin	10,000	Zinc sulphate	20
Aluminium acetate	6,000	Sodium borate	14
Cupric sulphate	2,000	Sodium chloride	6
Calcium hypochlorite	1,000		

In employing chemical disinfectants it is important to ensure their being added to the infected material in adequate quantity, and it must be borne in mind that it is the percentage of disinfectant in the entire bulk of material which determines the sufficiency of disinfecting power and not the percentage in the added disinfecting fluid. Again, the disinfectant should remain in contact with the infected material for a sufficient time to enable it to produce the desired effect. To be of practical value for public disinfection the disinfectant must be capable of killing organisms within a limit of about half an hour ; must not be poisonous to man or animals ; must be cheap ; easily dissolved in water ; must not injure the articles to be disinfected or the vessels in which it is placed and should not give rise to an offensive smell. Chemical disinfectants are usually applied in a liquid form. Disinfecting powders are, however, sometimes used ; many of them are of but little value. Calvert's carbolic acid powder and Macdougall's powder are said to possess the advantage that they do not contain lime, as do many inefficient carbolic acid powders, more suitable substances for bases being silicious matter, absorbent wood fibre or peat.

The South African Government scheme of tender for disinfectants requires in addition to germicidal strength much other information. The nature of the tests demanded by the Union of South Africa Government are as follows :—

The germicidal strength shall be stated in terms of a carbolic acid coefficient, as ascertained by a recognised method which must be specified in the tender. Tender samples shall be tested in the Government Laboratory by the method of Anderson and McClintoc (United States Hygienic Laboratory method, 1921) and also in the presence of organic matter by the method used by the British Admiralty.

In addition to the germicidal strength the following properties will also be investigated in the Government Laboratory :—

(*a*) Homogeneity and occurrence of sedimentation in bulk and under varying conditions of storage and use.

(*b*) Complete miscibility with formation of a fine and lasting emulsion with tap water, sea water, very hard or brackish water, standard soap solution or urine.[1]
(*c*) Relative freedom from harmful or poisonous properties for men and animals.
(*d*) Absence of corrosive action on metals.
(*e*) Insecticidal properties as regards fleas, lice, ticks, flies and their eggs.

Hydrogen-ion Concentration.

This term expresses the concentration, relative to normality of the dissociated part of the hydrogen replaceable by alkali metal, that is of the part which gives to a solution active acidic properties. This, in the case of weak acids, may be only a small proportion. The expression p_H, with a number or "exponent," is used to denote the concentration. The exponent is the logarithm of the reciprocal of the grammes of hydrogen ion per litre of solution (since a normal solution contains 1 gm. H per litre); e.g. p_H3 indicates a hydrion concentration of 1/1000 N, p_H7 1/10,000,000 N or neutrality. The p_H can be determined electrically with a hydrogen electrode and potentiometer or colorimetrically with indicators and "buffer" solutions.

Gaseous disinfectants are often employed for the practice of fumigation, more particularly in connection with "room disinfection." The notion entertained, in the past, has undoubtedly been that all that was requisite was to secure disinfection of the air of the room. With acceptance, however, of the particulate nature of infective material and study of the physical properties of micro-organisms, it has been realised that but little in the nature of practical "disinfection" can be accomplished in this way. It is not, of course, the organisms floating at a particular time in the air of the room that should be thought of as being specially important; these are inconsiderable in comparison with the total number of organisms present, and the mere destruction of the air-borne germs is a matter of comparatively little moment, the object to be attained being to deal as far as possible with all the organisms in the room. Hence dust and dirt of all kinds—that in chinks and crevices, as well as that suspended in the air or lying superficially—requires to be disinfected. Again, infective secretions and excretions may have soaked or penetrated into situations in which there is no likelihood of their being followed up and acted upon by gases evolved in the process of fumigation. While this process is especially useful for destroying organisms in exposed positions, experiments have shown that some penetration does occur.

Other methods of room-disinfection are also used. In Germany the plan of cleansing the surface of walls, etc., by rubbing them down with the crumb of bread has been extensively employed; and in Paris and elsewhere reliance is placed upon the use of disinfectant solutions, which are applied systematically to walls, etc., to the exclusion of the use of gaseous disinfectants. In Paris, perchloride of mercury has been largely employed in the form of spray, but it cannot be applied to many metallic and other objects without causing injury, and the poisonous character of the liquid has been objected to as a possible source of danger.

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[1] See also "Notes on the Bacteriological and Physical Testing of Disinfectants," by M. Wynter Blyth.

The disinfecting agent employed in the disinfection of room surfaces must be a powerful germicide, for it must operate within the course of a few hours. Any liquid used should be one with a low surface tension, enabling it to spread rapidly.

In this country formalin is widely used for spraying rooms ; it has the advantage of not altering the colour of any article wetted.

Floors and other horizontal washable surfaces should be scrubbed with a suitable disinfectant solution.

Gaseous disinfection is, however, very extensively practised in this country, sulphurous acid or formic aldehyde being generally used.

Sulphurous Acid—Sulphur Dioxide.—This gas may be generated by burning ordinary roll sulphur in an iron vessel, the ignition of the sulphur being favoured by moistening it with a little spirit; or sulphur candles made by mixing sulphur with inflammable material, may be used. Again, carbon bisulphide may be burnt in an ordinary benzoline lamp, sulphur dioxide being thus evolved. Another method is the use of cylinders containing liquefied sulphur dioxide. Although dry gas suffices to destroy insects and small mammals, for use as a germicide water vapour must be present, the disinfecting agent being sulphurous acid. The water vapour can be supplied by placing open pans of boiling water in the room or by a fine spray of water. As the gas is twice as dense as atmospheric air, it is well to arrange for its being liberated at some height in the room. The colour of any damp curtains, carpets or coloured stuffs is altered by the gas ; steel, brass, bronze and other bright materials and common gilt objects are tarnished ; these articles should be removed and disinfected by some suitable liquid disinfectant. Textile fabrics and furniture are liable to injury by the accompanying sulphuric acid, when the gas is produced by burning sulphur.

All outlets must be carefully closed, including the fireplace ; cracks must be pasted over with paper, and the room converted, as far as possible, into a hermetically-sealed chamber. At least 2 lbs. of sulphur (or two 20-oz. cylinders of the liquefied gas) should be used for every 1,000 cubic feet of space. The room can then be made to contain about 2 per cent. of the gas, and it should be kept sealed for twenty-four hours. If the work has been thoroughly done, there may be difficulty in entering the room to ventilate it ; in that case a towel well wetted with washing soda may be used to protect the mouth of the operator. After the room has been properly ventilated, the articles in it should be removed to the wash-tub or to the disinfecting chamber; the walls may require stripping as in small-pox; the floor should be thoroughly scrubbed; and it is desirable that articles of furniture should be well wiped with some suitable liquid disinfectant, care being taken not to cause unnecessary injury, as, for example, by the application of perchloride of mercury to metallic surfaces.

In this country as in many others sulphur dioxide has always been the routine fumigant for ships and in empty holds of cargo ships carrying no passengers; when 18–24 hours can be given to the process the method is effective and cheap.

Clayton's apparatus has been widely used for the purpose. The air in the hold is drawn into the generator, where sulphur is burning, whence it passes as sulphur dioxide (about 16 per cent.) and trioxide (and nitrogen); it is cooled by passing through a series of tubes, and then forced back into the hold. This is effected by means of a Root's blower, or in the smaller machines by a fan; sulphur dioxide is pumped in until a concentration of 3 per cent. is obtained.

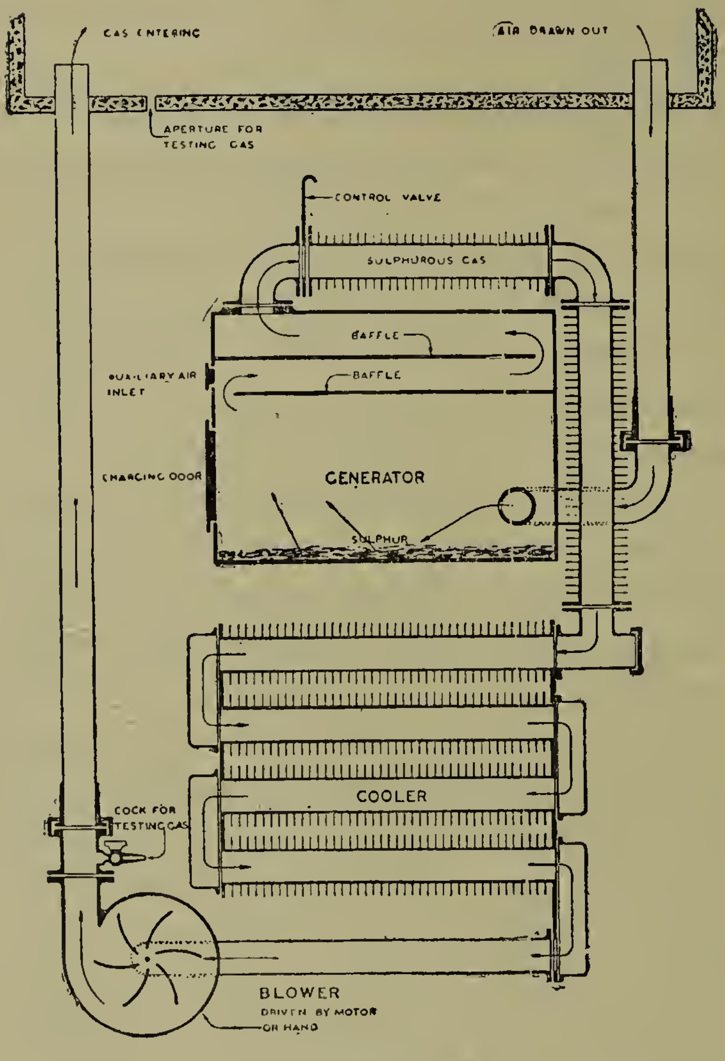

FIG. 87.
Diagram of mode of action of Clayton's Apparatus.

The use of chlorine as a disinfectant for rooms has been abandoned owing to its effect upon the respiratory system and the damage caused to fabrics, etc.

Using sulphurous acid and chlorine, however, under the most favourable conditions, will only cause the destruction of the less resistant forms of bacteria and these only if they are exposed to the action of the fumes. The unsatisfactory nature of the bactericidal effects observed with the use of these gases has led to numerous attempts being made to obtain a more reliable form of gaseous disinfectant. Of the various gases tried, only one—formic aldehyde—need be mentioned.

Formic aldehyde (CHOH) is now very largely used. It possesses some slight superiority to sulphurous acid from a germ-destroying point of view; moreover, it is less dense, and diffuses more readily; further, its irritating effects on the respiratory mucous membrane are less marked and it is thus more easy to work with.

It is a pungent gas; its aqueous solution can be concentrated until it contains 40 per cent. of the aldehyde. The liquid is then known as formalin. Disinfection by formaldehyde in the form of gas is often carried out by the evaporation of aqueous solutions, but the formaldehyde tends to polymerise and be converted into less active paraformaldehyde. Trillat observed that when heated under a pressure of about two atmospheres nearly the whole of the formaldehyde can be liberated as gas without this polymerisation taking place and that the addition of neutral mineral salts such as calcium chloride assisted the liberation of the gas. "Formochloral"—formalin with 10 per cent. of calcium chloride, 1 lb. for every 1,500 cubic feet, is heated in an autoclave and the gas introduced into the sealed room by a fine copper tube passing through the keyhole.

A simpler means of liberating the gas consists of placing crystalline potassium permanganate (40 grains) in a metal bucket or basin and pouring formalin (100 c.c.) on to it. 500 c.c. of formalin are required for every thousand cubic feet of air space. About one-fifth of the formaldehyde is oxidised to formic acid; the heat evolved vaporises the remaining formaldehyde and water.

Paraformaldehyde, a white solid, is made up into tablets which when heated in an Alformant lamp by methylated spirit are volatilised chiefly as active formaldehyde. The water resulting from the combustion of the spirit is often relied upon to supply the necessary amount of moisture, but it is safer to use a Hydroformant lamp in which an annular vessel holding a quantity of water is fixed; the water is converted into steam at the same time that the gas is formed from the tablets. Ten grams per 1,000 cubic feet should be used at least; an exposure of six hours is necessary to allow the gas to permeate into all the dead spaces of the room; in special cases the walls and floors should be sprayed with a half per cent. solution of formalin before using the lamps. For successful disinfection with formaldehyde gas—in other words, to prevent polymerisation—adequate heat and moisture must be present; a temperature of 60° F. and a relative humidity of not less than 60 per cent. are necessary. Formaldehyde has no detrimental effect on fabrics or colours nor does it attack metallic surfaces with the possible exception of iron or steel.

Wynter Blyth in 1897 found that "as a disinfecting gas" formic aldehyde was far superior to sulphurous acid. Kenwood obtained perfect sterilisation of diphtheria swabs by the use of Trillat's autoclave and also by using paraform tablets. Rideal's experiments with paraform tablets also showed their efficiency for surface disinfection in the case of the less resistant bacteria, but sporing organisms (B. anthracis and B. subtilis) were not invariably killed even with an exposure of twenty-four hours. From these experiments it was also evident that the penetrating power of the vapour is not sufficiently great to be able to sterilise infected fabrics.

Hydrocyanic acid has for some years been used chiefly abroad for the fumigation of shops and buildings to destroy bugs, and of late it has replaced to a considerable extent sulphur dioxide as a raticide for the disinfestation of ships, as sulphur dioxide has the disadvantage of damaging machinery and spoiling paint work. Hydrocyanic acid can also kill both fleas and their eggs; it has practically no germicidal action but is a powerful insecticide and very poisonous to mammals, and its use has been attended by fatalities.

For ship disinfection a series of experiments on a ship using alternately the simpler dumping fixture, and the more elaborate Liston's cyanide fumigator, demonstrate the greater safety resulting from the use of the latter apparatus, in that the rapid dilution of the gas prevents the occurrence of pockets of gas in high concentration. The disinfector must, however, always be protected from any concentration of gas. " Efficient protection resolves itself into a suitable apparatus, kept in perfect order and an efficient routine punctiliously carried out. A fraction of a minute's indulgence in the contempt for prussic acid gas born of familiarity may be fatal. It should be borne in mind that this gas in high concentration rapidly deadens the sense of smell, so that a man may easily be deceived as to the lethal nature of the atmosphere he is breathing." (J. Barcroft).

Klein, Houston and Gordon reported to the London County Council in 1902 upon the value of various disinfectants, under the ordinary conditions of their use in dwelling-houses. They tested the operation of four fluid disinfectants—carbolic acid, permanganate of soda, bleaching powder, and corrosive sublimate, and two gaseous disinfectants—formalin and sulphurous acid. The organisms experimented with included anthrax spores, the bacilli of tubercle, diphtheria, and typhoid fever, and the vibrio of cholera; cultures of the organism distributed in broth, in milk, or in melted gelatine (in the case of tubercle bacilli, tuberculous sputum was used) were liberally applied to four different kinds of material, in ordinary practice requiring to be disinfected, *viz.*, cloth, unvarnished or unpainted wood, linen, and wall-paper; these materials were then exposed to the action of the disinfectants and the result tested by cultural and inoculation experiments. It was found that the resistant anthrax spores " were only destroyed with certainty by perchloride of mercury " (1 in 1,000, with twenty-four hours' exposure), the other disinfectants either failing to destroy them or being uncertain, " and almost invariably failing when wood and cloth [1] were the materials to be disinfected." In the case of the tubercle bacillus, carbolic acid (5 per cent. solution, with twenty-four hours' exposure) and perchloride of mercury " were the only disinfectants efficacious on each occasion " ; neither formalin nor sulphurous acid manifested ability to deal with wood or cloth infected with this bacillus. Formalin vapour, however, showed to greater advantage than sulphurous acid in the case of tuberculous sputum dried on linen and paper. The gaseous disinfectants proved effectual in the case of the remaining organisms, save in one experiment, in which even the little resistant bacillus typhosus, exposed on wood or cloth, was not destroyed by formalin.

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[1] The contrast observed between wood and thick cloth on the one hand and linen and paper on the other was attributed to the fact " that the microbe-containing mixtures soaked into the materials first named."

Terminal Disinfection—The process of disinfection starts during the illness of the patient by the collection of infected discharges and the disinfection or the destruction of all articles soiled in their collection ; in this way the infection is prevented as much as possible from spreading from the vicinity of the patient. C. V. Chapin is the protagonist of the view that terminal disinfection is in some diseases unnecessary.

On the ground that laboratory findings show that the life of the pathogenic organisms outside the body is far less persistent than is generally believed and in consequence fomites are of much less importance than formerly supposed, he gave up the practice of surface disinfection of rooms after diphtheria in 1905 and after scarlet fever in 1908. The purpose of terminal disinfection is to prevent the recurrence of the disease in the family or its development in those who enter the apartment. Chapin considers that the following figures indicate quite clearly that the entire omission of disinfection does not increase the number of recurrences in the family. The figures for Baltimore, as do the corrected figures for Providence, include the development of the disease in other families living under the same roof. This, he holds, is evidence that the omission of disinfection does not increase the spread of disease in the neighbourhood.

Providence (U.S.A.) contains about 235,000 inhabitants, living for the most part in dwellings with tenements or apartments for two to six families. In the following tables only those recurrences are noted which occur in the immediate family within 60 days after the termination of isolation.

A contrast is made with Baltimore where terminal disinfection is carefully performed and tested by bacterial smears placed in the room.

The Providence figures as published are not directly comparable with those of Baltimore, but when corrected are—for diphtheria 0·16 per cent. less, and for scarlet fever 0·11 per cent. more than given below.

DIPHTHERIA.

Recurrences after Disinfection.

Baltimore.

Years.	Cases.	Recurrences.	Ratio.
1903–9	6,931	122	1·76

Providence.

Years.	Infected families.	Recurrences.	Ratio.
1902–5	1,457	25	1·71

Recurrences. No Disinfection.

Providence.

Years.	Infected families.	Recurrences.	Ratio.
1905–12	3,658	64	1·75

SCARLET FEVER.

Recurrences after Disinfection.

Baltimore.

Years.	Cases.	Recurrences.	Ratio.
1903–9	5,792	84	1·44

Providence.

Years.	Infected families.	Recurrences.	Ratio.
1904–9	2,428	36	1·48

Recurrences. No disinfection.

Years.	Infected families.	Recurrences.	Ratio.
1908–12	1,704	26	1·53

The danger is in the multiplicity of foci, and these, in the diseases under consideration, are chiefly carriers and missed cases.

Kenwood, opposing Chapin's view, says there are many factors which determine the varying prevalence of infection and room disinfection cannot be expected to be one of such dimensions as to exercise appreciable effect upon epidemic prevalence. "The only experiments that can satisfy must consist in selecting two separated communities as homogeneous quâ social circumstances, housing, age and sex constitution as possible, selecting such infections as scarlet fever and diphtheria; applying our best means of surface disinfection of rooms in one of the communities and neglecting every such precaution in the other; collecting the facts of those who remain at risk in the infected homes of both groups having regard to ages, immunity acquired from previous attacks, risks run prior to disinfection, cases which develop the disease subsequent to the disinfection within and beyond a period which would exclude the probability of infection prior to such disinfection; careful efforts to detect missed cases and carriers—then to compare carefully the results in the two groups over a year or two." [1]

In Brighton since 1910 disinfection of the mattresses, bolsters, and palliasses after removal to hospital of patients suffering with scarlet fever and diphtheria has been discontinued. No increase in the number of second cases in the families has occurred even when those occurring within the first seven days after the patient's removal to hospital and which might have been due to direct contact are excluded.

Sunlight can act as a germicide and even destroy the spores of organisms. The effective elements of the spectrum are the blue-violet and ultra-violet rays. The time required for the purpose varies with the different organisms; plague bacilli and cholera vibrios are more rapidly killed than tubercle bacilli. This bactericidal action can only occur when the sunshine is prolonged over a considerable period of time at maximum intensity. Unfortunately here the sunlight is so uncertain and the force of the sun's rays so variable that it cannot be depended upon as an aggressive measure in attacking infection.

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[1] Kenwood, "Public Health," February, 1924, p. 112.

Although diffused light retards the growth and development of bacteria and if strong enough will eventually kill them, and electric light containing actinic rays has similar powers, they are obviously of less importance as aggressive agents in disinfection than sunlight. The part they play in the destruction of bacteria occurring naturally has not yet been determined; it is possible, however, that sunshine and moving air exercise a desiccating effect and so assist in the eventual destruction of bacteria.

CHAPTER XI

VITAL STATISTICS

Rates—The rate at which births, deaths, etc., occur in a particular community is usually expressed in terms of a year and a thousand persons living. Thus :—

$$\text{Annual death-rate} = \frac{\text{number of deaths in the year}}{\text{population in the middle of the year}} \times 1{,}000.$$

In calculating weekly, quarterly, etc., death-rates, the standards employed are still the year and 1,000 persons living. Hence, a weekly death-rate, x, signifies not that x deaths per 1,000 living occurred during the week, but that, had the rate of mortality during the week been maintained for a year, x deaths per 1,000 living would have been recorded. Again, a " quarterly birth-rate " of 32 implies that 8, not 32, births per 1,000 living occurred during the quarter in question.

The following remarks concerning death-rates were made by W. Farr :—" The simple process of comparing the deaths in a given time, out of a given number living, is a modern discovery ; and as some individuals died at all ages in the healthiest, or attained the highest ages in the unhealthiest classes, and epidemics desolated the country as well as towns, though to less extent, the unaided reason was baffled in its attempt to unravel the intricate facts, and to draw conclusions which could justify or stimulate public interference. If the law of nature had been that all the inhabitants of an unhealthy place attained the age of 40 years, and of a healthy place the age of 50 years, and then invariably died, the difference would have been perceived in two or three generations : but the law of nature was different ; in both cases infants died at the breast, men perished in the prime of life, and old men grew grey with age ; the proportions only varied, and the difference was in the average duration of life, which varied from 20 to 50 years and yet remained undetermined." He added that it was not realised, for example, before the first report of the Registrar-General appeared, how considerable was the difference between the mean duration of life in the east districts (25–30 years) and that in the west districts (40–50 years) of the metropolis.

The main caution to be borne in mind in using rates, is that while they constitute a weapon of enormous value, provided the facts be sufficiently numerous and the period reviewed extend over a sufficient length of time, the liability to error is increasingly greater as they are calculated on smaller and smaller figures.[1]

Population—Before calculating rates it is necessary to ascertain the populations upon which they are to be estimated. The first census was taken in this country in 1801, and a fresh census has been taken every ten years since ; the details ascertained have varied somewhat in the different enumerations, and there has been, on the whole, a tendency to add to the particulars collected. This tendency will, no doubt, continue as time goes on, but it has been necessary to proceed by degrees, for, as Noel Humphreys has pointed out, " in England, at any rate," census statistics " are simply the tabulated results of facts furnished by householders," and " the imperfect education of a large proportion of householders in this country necessarily impairs the accuracy of much of the information collected " ; he cites, for example, the information given with regard to occupations ; speaking generally, the more detailed the information sought, the greater become the possibilities of error.

The following inaccuracies with regard to " ages " should be particularly noted. Children in their first, second, and third year are often returned as one, two, or three years old ; thus, in the first year of life especially, the census gives too low a figure. Again, there is a tendency to return ages as some multiple of ten, for as Ogle, in the Report on the 1891 Census, noted, it is necessary to realise that " not improbably the greater number of adults do not know their precise age, and can only state it approximately." Again, there is a certain amount of wilful misstatement of age ; thus, as Farr pointed out, the number of girls aged 10–15 at the 1841 census fell short by more than 25,000 of the number of young women returned at the age-period 20–25 in the 1851 census ; the fact suggests that, " in 1841 and 1851, heads of families returned several thousands of ladies of the higher ages at the age of 20–25." The influence of the immigration of young women from

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[1] It is a familiar device, therefore, with apologists for insanitary conditions to reduce the number of facts under review to such an extent as to confuse the issue. Thus, in a particular population living in an "insanitary area," the phthisis death-rate may be excessive, but this high rate, while apparent enough for the whole population, may not be so obvious on limiting consideration to particular houses in the area. If it can be elicited, for example, that only two deaths from phthisis occurred in a row of houses, occupied by forty persons, during a period of five years, such a discovery may be used to minimise the significance of the high rate in the entire population. The particular figures in question give, as a matter of fact, for the forty persons, a greatly excessive phthisis death-rate (10 per 1,000 per annum). It would, however, have been possible, by excluding the houses in which the deaths occurred, to show that no deaths at all could be associated with the remaining houses. Of course, but little importance can in any case be attached to a death-rate from one particular cause of death, based on a population of only forty persons when it relates to a period of but five years.

Scotland, Ireland, etc., into this country must not, however, be lost sight of. Finally, persons at advanced ages are very apt to overstate their age. This question will be seen to assume importance in connection with life tables.

Inasmuch as the population is enumerated at the end of the first quarter of census years, an estimate is necessary to determine the number at the middle of the year (*i.e.*, at the end of the second quarter). Moreover, estimates must be made of the populations at the middle of intercensal years, and in making the calculation it is assumed that the population increases or decreases in geometrical progression.

On this assumption the rates of quarterly increase and of annual increase are determined from the known rate of decennial increase. Thus, if the census populations be P and P^1, the rate of decennial increase $= \frac{P^1}{P}$, the rate of annual increase $= \sqrt[10]{\frac{P^1}{P}}$, and that of quarterly increase $= \sqrt[40]{\frac{P^1}{P}}$.

$$\begin{aligned} \text{Hence log ratio of decennial increase} &= \log P^1 - \log P, \\ \text{log ratio of annual increase} &= \frac{\log P^1 - \log P}{10}, \\ \text{and log ratio of quarterly increase} &= \frac{\log P^1 - \log P}{40}. \end{aligned}$$

Thus, it may be necessary, for example, given the census populations of 1891 and 1901, to find the population at the middle of 1904. Here the population at the census of 1901 must be multiplied by the ratio of quarterly increase, and again by the cube of the ratio of annual increase, since, from the time of taking the 1901 census to the middle of 1904, one quarter of a year and three whole years have elapsed. Taking logarithms, therefore—the log of the population required = log population at census of 1901 + log ratio of quarterly increase + 3 times log ratio of annual increase.

The length of the interval between successive censuses is apt to prove a source of considerable error. In London an intermediate census was taken for the first time in 1896, at the end of five years from the 1891 enumeration. The 1896 census did not, however, cover the whole ground of an ordinary census. The estimation of a population over a period of ten years without definite ascertainment of its actual numbers in the interval may yield startling results. Thus the Liverpool death-rate was supposed to have fallen from 26·7 in 1881 to 23·6 in 1890, the population of the city being estimated on the assumption that the increase of the previous decade had been maintained. As a matter of fact, it was found, in 1891, that the population had actually decreased, and that the death-rate, instead of falling to 23·6, had risen to 27·8. To some extent estimated populations may be checked by noting variations in the birth-rate, or in the number of inhabited houses as ascertained from the rate books.

Births must (since 1874) be registered within forty-two days of their occurrence. Still-births are not included in the returns in this country. The birth-rate is only slightly affected by season; there is a tendency for a maximum to occur in June and July, and a minimum in February or March. Social position has marked influence, the main factor being apparently the later ages at which the well-to-do marry. There has been in most countries, during the years of registration, a general tendency to decline in the birth-rate; this decline has been particularly noticeable in France, in parts of the United States, and in some of the Colonies. Newsholme considers that postponement of marriage and increased proportion of celibacy "only account for a share of the decreased birth-rate," and he holds that explanation of the phenomenon is to be sought "in some other cause or causes in operation throughout the civilised world."

More males are born than females; during the years 1838–47, 1,050 males were born to every 1,000 females in this country, but since that time the proportion has gradually declined, until in 1891–95 it was only 1,036 males to 1,000 females.

Marriages—The marriage-rate is usually given as the number of persons married per 1,000 persons living; a more accurate method is to calculate it on the number of marriageable persons over fifteen years of age. The marriage-rate is always higher in towns than in the country, and it is markedly influenced by national prosperity. Having attained a maximum of 17·6 in 1873, it has shown a tendency on the whole to decline since that date, though there have been notable fluctuations during and following the War years. The mean age at marriage has risen since 1873, and the proportion of marriages under age has shown steady diminution, from 82 men and 223 women who were minors per 1,000 marriages in the years 1871–75, to 56 men and 183 women who were minors per 1,000 marriages in the years 1891–95. It may be noted that in the early years of registration about one out of every three men, and one out of every two women married, were unable to sign the marriage register. The proportion has steadily diminished to less than 1 per cent. in both sexes; the proportion of women signing the marriage register with marks is still slightly in excess of that of men.

Deaths must be registered within five days of their occurrence. When a person who dies has been attended by a registered medical practitioner it is the duty of such practitioner to certify the cause of death. About 92 per cent. of the total deaths in England and Wales are certified by registered medical practitioners. In some 6 per cent. an inquest is held and rather more than 2 per cent. are uncertified deaths.

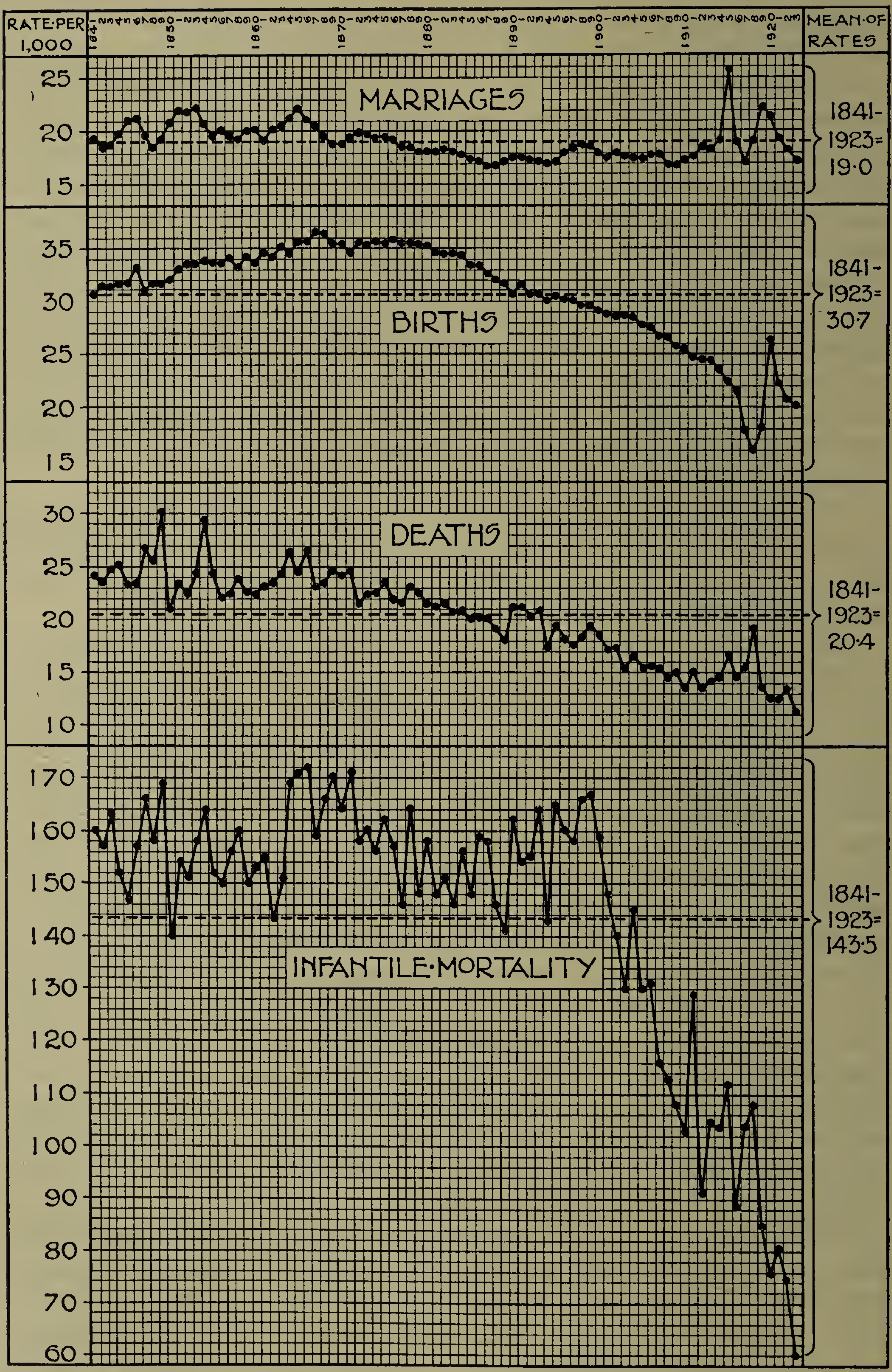

FIG. 88.—Marriages, Births, Deaths and Infant Mortality Rates, London, 1841–1923.

The absence of a certificate does not necessarily involve the holding of an inquest; the registrar may, save in certain circumstances, accept the statement of the person who informed him of the death, as to the cause.

A Committee of the House of Commons was appointed to consider the question of death certification, and reported in 1893. The Committee recommended that, in each sanitary district, a registered medical practitioner should be appointed as public medical certifier of the cause of death, in cases in which a certificate from a medical practitioner in attendance was not forthcoming. The Committee made a number of other suggestions, but effect has not yet been given to their recommendations.

The effect of emigration and immigration upon the death-rate in a locality is marked; hence the low death-rate of growing towns, whose population is being continually added to by numbers of young adults from country districts. In some localities the proportion of domestic servants, whose lives are, generally speaking, "good lives," is sufficiently large to materially influence the death-rate. Moreover, in the case of domestic servants, it is often found that when illness occurs the patient returns home, and her death, should the illness prove fatal, is registered there, and is thus not credited to the district in which she has been living.

The transference of deaths from indefinite to definite headings has been largely aided by the practice initiated by W. Ogle in 1881 of addressing inquiries to medical practitioners requesting further information respecting deaths. As an example of the result of this system it is stated that during the ten years (1901–10) "more than 5,000 additions were made thereby both to tuberculosis and to cancer, more than 1,000 both to puerperal septic disease and to appendicitis, about 900 to gastric ulcer, about 800 to alcoholism, and about 700 to venereal diseases.

Outlying Institutions and Non-residents—Public institutions are also sources of disturbance of death-rates. In order to obviate the difficulties in question, it is desirable that the deaths of strangers who happen to die in the district should be excluded, and that those of persons who belong to the district, but who die outside it, should be included. The correction is difficult to make in its entirety, but to some extent the source of error can be removed. In London for many years past each sanitary authority has been supplied quarterly, from Somerset House, with particulars of the deaths belonging to it, which have occurred in outlying institutions, and in the statistics published by the Registrar-General relating to the thirty-three great towns the deaths of non-residents occurring in county hospitals, county asylums, hospitals for infectious diseases, and convalescent homes, have been excluded from the deaths returned as belonging to the sub-districts in which such institutions are situated.

From the beginning of the year 1911, the attempt has been made to correct in the case of deaths occurring elsewhere than in public institutions by the inclusion of non-residents who really belong to a particular area, and the exclusion of persons not belonging to the area but temporarily housed therein. A system of transference was devised in 1911 by the Registrar-General and the Local Government Board which aims at crediting as far as practicable such transferable deaths in each instance to the appropriate sanitary area. This system, while necessarily not altogether complete, gives a more correct statement of the death-rate in each area than was obtainable prior to 1911. A similar correction is also now made in regard to birth-rates.

In particular instances, unless correction for outlying institutions and for non-residents be made, most fallacious conclusions are likely to be drawn. Thus an urban registration district containing a large general hospital, whose patients are only in small part drawn from the registration district itself, may show great excess of mortality, unless regard be paid to the question of the hospital deaths. On the other hand, the practice of isolating small-pox cases at a distance from centres of population may result, during times of small-pox prevalence, in practically no increase in a particular district in the death-rate due to this cause, unless regard be paid to the small-pox deaths occurring in the isolation hospital, which may happen to be situated in a registration district distinct from that to which the deaths really belong.

Infant mortality should always be estimated in proportion to every thousand births, inasmuch as the census returns relating to the first year of life are, as has been seen, particularly untrustworthy. Strictly speaking, the mean of the births of the current and the preceding year, or the births of the first half of the current and the last half of the preceding year, should be taken as giving the true infantile population ; as a rule, however, this more accurate method is not adopted, and the births of the current year are taken. The infantile mortality is often appealed to as a test of " sanitary condition." In particular towns high infant mortalities, even exceeding 200 per 1,000 births, recurred year after year until 15 or 20 years ago. In London the infant mortality in 1923 was only 61 per 1,000 births.

Neglect on the part of parents plays an important part in connection with infant mortality. G. Reid has drawn attention to the influence thus exerted in connection with employment of married women in factories in Staffordshire. He found that the infant mortality, in three groups of towns, followed the order in which the groups were arranged, from the point of view of number of women engaged in work away from home. It has been suggested that the observed coincidence is really due to the operation of other factors, inasmuch as populations can be selected, from other parts of the country, in

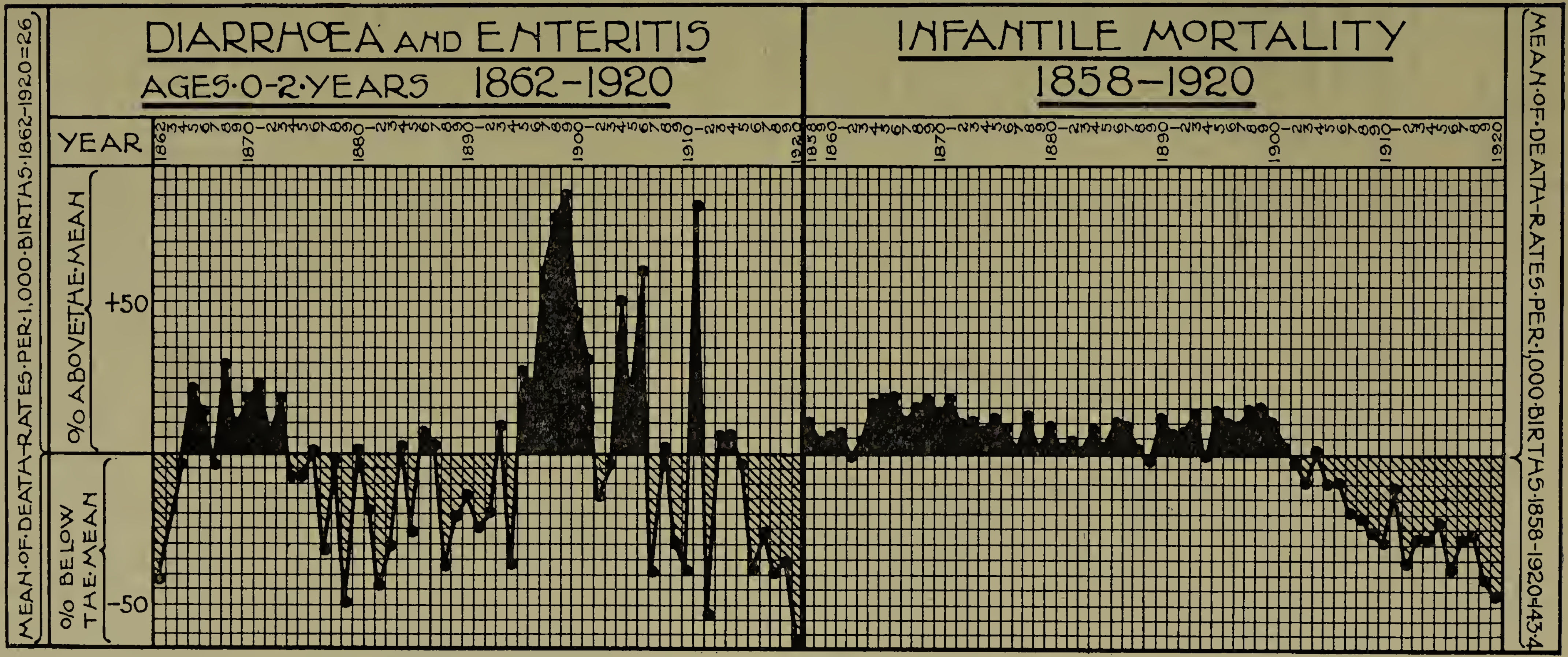

FIG. 89.—London. Deaths from Diarrhœa and Enteritis under two years of age, 1862–1920, and Infant Mortality, 1858–1920.

which high infant mortality exists in association with comparatively little employment of women in factories. The question raised in connection with the Staffordshire figures is, however, one to which importance must be attached.

There can, of course, be no doubt that other influences are also at work—improper feeding in particular is largely accountable for high infant mortality. Newsholme comments upon the striking statement that has been made that "during the sufferings and starvation connected with the siege of Paris in 1870–71, while the general mortality was doubled, that of infants is said to have been reduced by about 40 per cent., owing to mothers being obliged to suckle their infants." The same increase of adult and diminution of infant mortality was seen during the Lancashire cotton famine, when, as Newsholme notes, mothers were not at work at the mills. It is of course possible that in these instances the deaths of infants were not all registered. Two further points may be referred to: Year after year considerably more than 1,000 infants were "overlaid," *i.e.*, suffocated in bed. Ogle pointed out (53rd Annual Report of the Registrar-General, p. xv.) that these deaths were specially frequent on Saturday nights, and suggested that drunkenness of the parents probably exerted influence in this connection. Again, Farr has shown that the number of deaths of illegitimate infants, per 1,000 illegitimate births, is in marked excess of the number of deaths of legitimate infants, per 1,000 legitimate births.

The influence of birth-rate on death-rate has been much discussed. Alterations in the birth-rate, by affecting the age constitution of a population, affect the death-rate; thus, a high birth-rate, other things being equal, in a particular year, by causing immediate increase in the number of young children, whose rate of mortality is high, might be expected to increase the death-rate for a year or two. On the other hand, however, if the birth-rate continue high, after a few years the population comes to possess an unusual proportion of persons who have weathered the storms of infancy, and whose rate of mortality is now low. Thus, a high birth-rate, continued for a number of years, might be expected to produce a low death-rate. As a matter of fact, in many instances in which high birth-rates occur, other conditions which affect death-rates more than the birth-rate itself does also obtain, and hence the influence of the birth-rate *per se* is often obscured. Thus, in crowded urban districts, occupied by poor people, high birth-rates and high death-rates often coexist. The high death-rate in such cases obtains, notwithstanding the favourable age-distribution of the population produced by the high birth-rate, and is probably due to insanitary conditions. It has been pointed out that low birth-rates, continued for a number of years, have been observed to be associated with low death-rates. In France, however, a low birth-rate coexists with a somewhat high death-rate. In that country the low birth-rate has been very long-continued, and the proportion of persons at advanced ages (attended by high mortality) is in such marked excess of the normal proportion as to adversely influence the death-rate.

Combined Death-rates—In obtaining the combined death-rate of two districts, it is, of course, necessary to take into account the relative sizes of the populations. Thus, if one population consist of 10,000 persons with a death-rate of 20 per 1,000, and the other of 50,000 persons with a death-rate of 15 per 1,000, the combined death-rate is obtained by applying the total deaths 200 + 750, *i.e.*, 950, to the total population 60,000. The death-rate is then 15·8. It would be absurd, of course, to regard the mean of the two death-rates, 17·5, as the combined death-rate, save in the case in which the two populations happened to be equal.

Influence of Age and Sex—The tendency of the two sexes to suffer to a differing extent, from various diseases, must be noted. It is probably largely influenced by the degree of exposure to the conditions favourable to the development of certain maladies, and is also in part due to differences in predisposition. The excess of male mortality in small-pox, typhus, hydrophobia, glanders, anthrax, syphilis, gonorrhœa, and alcoholism is clearly in the main due to the former cause; but puerperal fever and diseases incidental to childbirth are, of course, limited to females. Measles and diarrhœa show excess among males under five; after five, measles mortality, and after ten, scarlet fever mortality, is greater in females. Diphtheria shows notable excess in females; here, again, greater exposure to infection, in connection with attendance on the sick, may be in part accountable. Nervous diseases, diabetes, tabes mesenterica, tubercular meningitis, and rickets are more fatal in males. Erysipelas, rheumatism, and anæmia cause higher mortality in females, as does also whooping-cough. The mortality from phthisis showed, until 1860, excess among females after the first few years of life up to the forty-fifth.

Tatham (Supplement to the 65th Annual Report of the Registrar-General) pointed out that the age of maximum incidence of phthisis had gradually shifted in successive decades from 1851–60 to 1891–1900, in both sexes from young adult ages to middle life in women, and somewhat later still in men. This phenomenon was doubtless in the main due to increase in the movement out of this country of phthisical persons, especially at the young adult ages, in the decades in question. With a falling off in the extent of this movement, which dates from about 1905 to 1910, the phenomenon in question became less marked, and the outbreak of the Great War accentuated the reversion to the age incidence of earlier years.

The influence of age upon mortality from particular diseases has been strikingly illustrated by Farr (Supplement to the Thirty-fifth Annual Report), in his account of the "March of an English Generation through Life." He there follows the progress of 1,000,000 children, and notes the diseases which affect them as their age advances. "The first thing to observe," he says, "is that the fatality children encounter is primarily due to changes in themselves." Of the million some "have been born prematurely; they are feeble; they are unfinished; the molecules and fibres of brain, muscle, bone, are loosely strung together; the heart and the blood on which life depends, have undergone a complete revolution; the lungs are only just called into play. The baby is helpless; for his food and all his wants he depends on others." Out of a million 149,493 die in the first year of age. "In the second year of life pneumonia, bronchitis, and convulsions are still the prevalent and most fatal diseases; many also die then of measles, whooping-cough, scarlatina, and diarrhœa. Scarlet fever asserts its supremacy in the second, third, fourth, and fifth years of age. Whooping-cough is at its maximum in the first year, measles in the second, scarlatina in the third and fourth years." The deaths from all causes, under the age of five years, are 263,182; in the healthy districts only 175,410; but in Liverpool 460,370, or "nearly half the number born, died in the five years following their birth."

At the age 5–10 the total deaths are only 34,309; scarlatina is the "principal plague of this age." At 10–15 the deaths are fewer than at any other age—phthisis accounts for about one-fifth of them. At 15–20 mortality increases, especially among women, of whom 5,263 die of consumption (phthisis); a few women already die in childbirth. At 20–25 nearly half the deaths are caused by phthisis; 1,100 women die in childbirth. At 25–35 consumption is the most fatal disease and is the cause of 27,134 deaths; at 35–40 "phthisis still predominates, fever still snatches its many victims, and the brain, heart, lungs, and bowels become more and more the seats of destructive disease; 564 persons commit suicide, 3,280 die violent deaths, 2,907 of them men and 373 women; 2,516 mothers die in childbirth." In the period 45–55, "the middle arch of life," the million lives are reduced to half a million; cancer, already fatal before, now destroys 4,583 lives. In the period 55–65 cancer kills 5,998, consumption 10,445. "The diseases most to be dreaded and guarded against, especially by men, are affections of the lungs and heart, of which 23,659 and 17,081 persons die. Diseases of the brain are fatal to 15,678; diseases of the stomach and intestines and liver are fatal to 11,400." Only 309,029 persons enter the period 65–75, and 161,124 leave it alive, the same classes of disease as were fatal from 55–65 prevail. Only 38,565 leave the next period, 75–85, alive; 2,153 live to 95, and

223 to 100. "Such and so various," says Farr, "are the settings of 40,858,184 years of English life." The account of which the above is a brief abstract, was written, it must be remembered, as long ago as the year 1875, and the figures used are those of the English Life Table, No. 3, to be presently referred to.

Correction for Age and Sex Distribution—As has been already noted, in connection with the influence of the birth-rate upon the death-rate, modifications in the age and sex distribution of a population materially influence its death-rate. The Registrar-General began, in 1883 (Annual Summary), to apply a method of correcting the recorded death-rate of the great towns for age and sex distribution.[1] This method can, of course, be applied to other populations, and it is often employed. The principle adopted is the construction for each town of a *standard death-rate*—*i.e.*, a rate calculated on the hypothesis that the deaths at each age-period, in each sex, occur at the same rates as those obtaining, not in the town itself, but in England and Wales, during the latest available decennial period. Thus, to the population of the particular town, rates of mortality in the country as a whole, are applied, and the result, the *standard death-rate* of the town, differs from the actual death-rate in the whole country, to a greater or less extent, according as the age and sex distribution in the town are more or less abnormal. As an example of the method of calculating a standard death-rate, the table on next page, which gives the necessary data in a particular instance, that of the town of Huddersfield, may be quoted from Newsholme's "Elements of Vital Statistics."

It will be found that the number of deaths so calculated, 1572, only yields a death-rate of 16·47, whereas the death-rate of England and Wales (1881–90) was 19·15. The Huddersfield population is thus far more favourably constituted, as regards age and sex distribution, than the population of England and Wales generally; for in place of a death-rate of 19·15, which is that yielded on application of the England and Wales rates to the England and Wales population, the Huddersfield population, on having the same rates applied to it, yields only a "standard rate" of 16·47.

The standard death-rates of the great towns are found to vary considerably. The lowest standard death-rate in the decade referred to by Newsholme was that of Huddersfield, just referred to; while the highest standard death-rate was that of Norwich, which was 19·99. Some of the towns yield standard death-rates differing but little from that of England and Wales; for the most part the standard death-rates in the towns fall short of this, owing to divergences (from the

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[1] For an alternative method which can be employed when the death-rates at age-periods, in populations whose recorded death-rate is to be corrected, are available, see Supplement to the Forty-fifth Annual Report, pp. xvii to xix.

Ages.	Mean Annual Death-rate in England and Wales, 1881–90, per 1,000 living at each group of ages.[1]		Population of Huddersfield in 1891.		Calculated Number of Deaths in Huddersfield.[2]	
	Males.	Females.	Males.	Females.	Males.	Females.
Under 5 . .	61·59	51·95	4,551	4,785	280	249
5 . . .	5·35	5·27	4,691	5,081	25	27
10 . . .	2·96	3·11	5,113	5,165	15	16
15 . . .	4·33	4·42	4,905	5,549	21	25
20 . . .	5·73	5·54	4,541	5,461	26	30
25 . . .	7·78	7·41	7,466	8,834	58	65
35 . . .	12·41	10·61	5,576	6,265	69	66
45 . . .	19·36	15·09	3,944	4,649	76	70
55 . . .	34·69	28·45	2,393	3,017	83	86
65 . . .	70·39	60·36	1,128	1,590	79	96
75 and upwards . .	162·62	147·98	250	466	41	69
Totals . .			44,558	50,862	773	799
			95,420		1,572	

England and Wales age and sex distribution of population) in these towns, of such a kind as to render them likely, *à priori*, to have a lower death-rate than that of England and Wales. The standard death-rate for the population of the thirty-three towns taken altogether was only 17·72; that of England and Wales, less the thirty-three towns, being 19·46.

The Registrar-General divides the standard death-rate in England and Wales by the standard death-rate in each town, and calls the result obtained the *factor for correction* for the particular town, *i.e.*, it is the figure by which the recorded death-rate should be multiplied in order to correct for variations of age and sex distribution. When the recorded death-rate of a town is multiplied by the factor for correction, the result is the *corrected death-rate* for that town. Again the Registrar-General gives for each town a *comparative mortality figure*, which represents its corrected death-rate for the particular year in question, compared with the recorded death-rate at all ages in England and Wales taken as 1,000. Thus, in Huddersfield in 1900 the recorded death-rate was 16·78; this must be multiplied by

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[1] The death-rates for England and Wales are the means of the annual death-rates in 1881–90 (Reg.-Gen. Fifty-fourth Annual Report, Tables 11 and 12).

[2] The "calculated deaths" are taken to whole numbers only.

$\frac{19{\cdot}15}{16{\cdot}47}$, *i.e.*, 1·1627 (the factor for correction), in order to obtain the corrected death-rate, which proves to be 19·51. On comparing this with the England and Wales rate, 19·15, it is found that it stands to it in the proportion 1,018 to 1,000. Hence 1,018 is the comparative mortality figure for Huddersfield for 1900.

Causes of Death—In this country the tabulation of causes of death was commenced in 1593, when the weekly bills of christenings and burials were instituted by the parish clerks of London. The series was continued uninterruptedly from the year 1603. At first the plague was distinguished, and then other diseases and casualties. A glance at the entries in "the bills" (chrisomes, worms, teething, moldshot-head, liver-grown, canker, thrush, etc.), and comparison of them with the nomenclature of a modern hospital report shows, as Sir John Simon said, how great an advance has been effected as regards accurate definition of the cause of death. "Pathological anatomy, chemistry, the stethoscope and other instruments of investigation" have, of course, "greatly facilitated the analysis of diseases."

It is important to note as regards zymotic diseases, that it is common to apply the term *zymotic death-rate*, not to the mortality from the entire zymotic group of the Registrar-General, but to the death-rate from what are styled the seven principal zymotic diseases—smallpox, measles, scarlet fever, diphtheria (including membranous croup), whooping-cough, "fever" (typhus, simple continued, and enteric), and diarrhœa [1] (including cholera).

In death certificates headings such as dropsy, convulsions, palsy, etc., often appeared. Farr held that refusal to accept such terms would tend to foster "reckless conjecture" in making returns; it was, however, he said, desirable that the use of the names of symptoms should be avoided "wherever the names of diseases or of causes of symptoms could with reasonable certainty be substituted." The form of death certificate in use provides for the insertion of a primary and secondary cause of death; these, it is suggested, should be entered "in the order of their appearance, and not in the presumed order of their importance." In classifying the death, however, only one cause can be selected.[2] In making this selection zymotic diseases are to be preferred to other diseases, specific to non-specific, and primary to secondary diseases.

In 1881 a system of making further inquiries in doubtful cases was instituted by the Registrar-General; particulars as to the results obtained are given on p. 18 of the Annual Report for 1895. Faulty diagnosis, the desire not to hurt the susceptibilities of relatives, and lack of uniformity in nomenclature, are still frequent sources of fallacy. As Newsholme says, there is " a fashion even in the names of diseases." Again, to quote Noel Humphreys : " Causes of death in the death register are necessarily little more than the more or less trustworthy guesses of a large body of more or less skilful observers, except in the small proportion of cases in which these guesses are corroborated or modified by post-mortem examinations. Statistics of causes of death should, therefore, be compiled with caution and without any attempt at over-elaboration of detail. Still greater caution should be used in drawing inferences and deductions from a comparison of the results for a series of years. Changes of nomenclature and of classification add materially to the difficulties in the way of useful comparison of such statistics for different periods of years."

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[1] Deaths from diarrhœa are no longer included.

[2] The causes of death are Deaths classified according to the second revision of the International List (1909).

Particular instances of the need for exercise of such caution have already been given in commenting upon variations in the recorded mortality from certain special causes of disease. Improved diagnosis is no doubt mainly accountable for the diminution in the mortality recorded from croup, convulsions, simple continued fever, and ill-defined causes, and is largely responsible, at any rate, for the increase in the mortality recorded from cancer, diabetes, urinary diseases, and puerperal fever. In pulmonary tuberculosis both improved diagnosis and preventive measures have doubtless played a part. The latter are presumably mainly accountable for the reduction in small-pox, scarlet fever, diarrhœa, typhus, and typhoid fever. It is noteworthy that in measles and whooping-cough, diseases in which preventive measures have not as yet been very systematically attempted, the registered mortality continues to be high. Noel Humphreys further says : " The materials with which Farr had to work nearly fifty years ago were defective enough to have discouraged a less sanguine and indefatigable statistician ; but while he was able from time to time to improve the quality of his materials, few will venture to deny the value of the results he obtained . . . even in the early years of his service. . . . In vital statistics all students must learn to use imperfect materials, and yet to guard, as far as possible, against fallacious results."

In the table on opposite page the annual death-rates from the principal zymotic diseases and the infant mortality, in England and Wales, during a series of years are given :—

Period.	Annual mortality per million persons living from the principal zymotic diseases.								Annual Mortality of Infants under one year of age to 1,000 Births.
	Small-pox.	Measles.	Scarlet Fever.	Diphtheria.[1]	Whooping-Cough.	Typhus.	Enteric Fever.[2]	Simple and Ill-defined Fever.	
1850	262	398	753		437	865			146
1851	389	521	758		440	997			154
1852	401	320	1,035		440	1,022			158
1853	171	266	853		609	1,008			160
1854	151	498	995		525	1,015			157
1855	131	391	894	20	541	875			154
1856	116	373	705	32	483	847			144
1857	202	310	652	82	526	988			156
1858	329	476	1,212	339	598	918			158
1859	193	485	976	517	456	806			153
1860	136	479	485	261	429	652			148
1861	64	450	451	225	612	767			153
1862	78	481	728	241	602	919			142
1863	286	550	1,478	315	547	874			149
1864	364	397	1,418	261	409	960			153
1865	301	405	837	196	409	1,089			160
1866	139	511	546	140	736	986			160
1867	114	304	567	120	548	778			153
1868	91	528	996	137	419	895			155
1869	67	464	1,244	117	493	193	390	239	156
1870	113	335	1,446	120	529	147	388	233	160
1871	1,012	408	815	111	455	121	371	186	158
1872	821	368	515	93	596	80	377	145	150
1873	98	316	562	108	411	70	376	132	149
1874	88	517	1,050	150	437	74	374	130	151
1875	35	257	851	142	594	62	371	108	158
1876	99	408	691	129	432	48	309	81	146
1877	173	366	585	111	460	45	279	78	136
1878	74	310	753	140	710	36	306	71	152
1879	21	362	694	120	503	21	231	58	135
1880	25	478	675	109	530	21	261	58	153

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[1] Diphtheria. This heading includes laryngeal diphtheria in later years Until the "eighties" much laryngeal diphtheria was returned as croup and hence in the earlier years the diphtheria deaths need to be approximately doubled to make them comparable with diphtheria deaths in the last twenty years. The transference of the croup deaths to diphtheria was practically accomplished between 1880 and 1900.

[2] Enteric fever includes typhoid fever, and in later years the paratyphoid fevers.

Period.	Annual mortality per million persons living from the principal zymotic diseases.								Annual Mortality of Infants under one year of age to 1,000 Births.
	Small-pox.	Measles.	Scarlet Fever.	Diphtheria.[1]	Whooping-Cough.	Typhus.	Enteric Fever.[2]	Simple and Ill-defined Fever.	
1881	119	280	548	121	415	21	212	44	130
1882	50	483	521	152	579	36	229	39	141
1883	36	350	475	158	393	33	228	36	137
1884	82	419	402	186	425	12	236	28	147
1885	103	533	233	164	481	12	175	24	138
1886	11	436	218	149	470	9	184	22	149
1887	19	602	282	160	404	8	185	18	145
1888	37	347	226	171	436	6	172	15	136
1889	1	518	235	189	430	5	176	15	144
1890	0	439	242	179	478	5	179	13	151
1891	2	436	170	173	468	5	168	11	149
1892	15	459	190	222	454	3	137	8	148
1893	48	373	234	318	342	5	228	9	159
1894	27	390	167	291	410	4	159	7	137
1895	7	377	149	259	315	2	175	5	161
1896	17	570	177	291	429	2	166	5	148
1897	0	407	147	245	367	2	155	4	156
1898	8	419	112	243	323	1	181	4	160
1899	5	313	117	291	318	1	198	4	163
1900	3	394	119	290	356	1	173	4	154
1901	10	277	133	273	313	1	155	3	151
1902	75	392	148	237	298	2	126	3	133
1903	23	275	125	183	286	2	101	2	132
1904	15	365	112	170	353	1	93	2	145
1905	4	326	113	161	256	1	90	2	128
1906	1	275	101	178	242	0	92	1	132
1907	0	364	93	165	296	1	68	1	118
1908	0	228	80	158	280	0	75	1	120
1909	1	356	91	148	203	0	60	0	109
1910	1	232	66	120	246	0	53	0	105
1911	1	363	52	135	217	0	67	0	129
1912	0	352	55	118	230	0	44	0	95
1913	0	291	57	121	149	0	41	0	109
1914	0	247	77	158	218	0	46	0	104
1915	0	462	66	165	230	0	35	0	106
1916	0	155	39	154	176	0	30	0	91
1917	0	308	22	132	134	0	28	0	91
1918	0	289	29	142	296	0	26	0	98
1919	1	96	33	133	71	0	16	0	93
1920	1	191	38	150	117	0	14	0	85
1921	0	59	34	126	121	0	16	0	83
1922	1	149	36	107	167	0	12	0	77
1923	0	138	26	71	108	0	12	0	69

[1] [2] See Notes at foot of previous page.

Occupational Mortality—In the supplements to the 35th, 45th, 55th, 65th and 75th annual reports of the Registrar General which deal with the statistics of successive decennia from 1861 to 1910, this subject has been investigated by Farr, Ogle, Tatham and Stevenson. In each instance, attention has been particularly directed to the ages 25 to 65, in males, as being those in which the influence of occupation has been especially exerted. Owing to the fact that in different occupations there are great variations in age-distribution within the age limits 25 to 65, the plan has been devised of calculating the death rates for each occupation in a standard population made up of that number of males aged 25 to 65 in populations generally among whom 1,000 deaths would occur annually. Taking the 1911 census and the deaths for the year 1910–12 as a basis, it is found that 1,000 deaths might be expected yearly in a standard male population consisting of 26,259 aged 25–35; 20,407 aged 35–45; 14,748 aged 45–55; 9,591 aged 55–65. Applying the death rate at each of these four age-groups as ascertained for a given occupation, to the standard population, the number is obtained which is called the "*comparative mortality figure*" for the occupation in question. For all males, the figure is of course 1,000. For occupied and retired males, 790; for occupations mainly represented by the upper and middle classes, 695; for skilled workmen, 758; for unskilled, 1,121.

Among the more important special occupations, the following may be mentioned in the order of their comparative mortality figures, calculated on the four age-groups already specified :—

Clergymen, priests, ministers, 443; gardeners, nurserymen, seedsmen, 457; agricultural labourers, farm servants, 470; schoolmasters, teachers, 506; barristers, solicitors, 627; medical practitioners, 693; shopkeepers, 708; printers, 773; tailors, 799; painters, decorators, 865; inn, hotel, etc., servants, 1,173; potters, earthenware, etc., manufacturers, 1,196; file makers, 1,529.

Similar statistics of occupational mortality among females have not been abstracted, since, in their case, the death register furnishes no adequate record of occupation.

Occupational mortality was also dealt with by Ogle (supplement to the 45th annual report) from the point of view of special causes of death, and the results of a more elaborate enquiry made into this matter by Tatham appear in the supplement to the 55th annual report of the Registrar General, similar figures being given in later supplements. Special consideration has been given to occupations involving risk of lead poisoning, and also to the effects of alcoholic excess, and the facts elicited with regard to occupations in which dust-laden air is breathed, are exhaustively analysed. The mortality figure of the agriculturist from phthisis and diseases of the respiratory system being taken at 100, it may be stated, quoting from some of the examples given, that the corresponding figure for the period 1910–12 for coal-miners is 154 ; for millers and cereal food manufacturers, 159 ; bakers and confectioners, 164 ; chainmakers, blacksmiths, etc., 179 ; lead workers and lead manufacturers, 212 ; shoemakers, 246 ; stone quarriers and masons, 301 ; tin-plate goods makers, 327 ; lead miners, 397 ; potters, earthenware manufacturers, 448 ; cutlers, scissor makers, 504 ; file makers, 512 ; and tin miners, 746.

The sources of error in statistics of occupation are many. To begin with, the way in which occupations are described in a census depends, as already noted, largely on the intelligence of the householders who make the returns, and the particulars regarding occupations in death certificates are often very vague and do not always contain information derived from the same source as that given in the census returns. Another point to be borne in mind is that masters and workmen, distributors and producers were not distinguished until 1891 and in the census of that year the attempt made to draw the attention of householders to this question does not appear to have been completely successful. Further, as pointed out in the Registrar-General's reports, some trades require great strength and must be abandoned by persons of failing health, who are transferred to and swell the mortality of other occupations. Further, some trades are never taken up at all by weakly persons and these consist from the outset of picked men, upon whom any ill-effects produced by the occupation are likely to be less marked than they would be in the average individual. It must also be borne in mind that there is a direct relationship between the mortality and the amount of wages earned, or the " social condition " of the worker, and this is the main factor in any differences of mortality between one occupation and another, the risks incidental to the occupation being relatively of less importance in a large number of cases.

Sickness Rates—The attempt to obtain records of sickness of all kinds, attended at the public expense, was inaugurated in 1857 by the Metropolitan Association of Medical Officers of Health. A similar attempt was made in 1860 in Manchester and Salford. These attempts did much to pave the way for the notification of infectious diseases. (See p. 691.) Notification returns relating to scheduled infectious diseases have now been available, throughout the greater part of the country, for more than thirty years (in a few towns for a longer period). There are, apart from the statistics of infectious diseases, certain records of friendly societies, which show, *inter alia*, the average number of days of sickness per annum in the case of members of various ages. This number is found to vary from some six or seven days at ages 20–30, up to some thirty to fifty days at ages 60–70. There are, further, sickness statistics available relating to the army, navy, police, etc. Moreover, since the passing of the Factory and Workshop Act, 1895, returns of particular kinds of sickness in certain industries have been made. Further development of the notification of sickness was advocated by Newsholme in a paper which appeared in the "Journal of the Statistical Society" for 1896.

The Registrar-General publishes week by week tables of notification figures relating to infectious diseases in boroughs, urban and rural districts, and port sanitary districts.

Evidence of the Health of Communities is afforded by applying various tests. The general death-rate, if it be based on sufficiently large figures and be corrected for institution deaths, and for age and sex distribution, is fairly reliable. The zymotic death-rate, to which importance is often attached, is apt to mislead. Some of the zymotic diseases, considered individually, stand in much closer relation to what are generally regarded as insanitary conditions than others; the tendency of most of them to occur in epidemics, makes a zymotic death-rate, unless the period of time under review is a long one, unreliable. Infantile mortality is largely influenced by epidemic diarrhœa, whooping-cough, and measles. The phthisis death-rate and the death-rate from respiratory diseases are sometimes appealed to. They are certainly more reliable than the zymotic death-rate. For precise purposes, however, a more exact guide to health conditions is needed, and, in connection particularly with life assurance, a method of measuring accurately the mean duration of life is required. This is furnished by the Life Table.

Life Tables—If a million children be supposed to be all born at the same point of time, and to be followed through life, it is possible to predict the number of the survivors as successive ages are reached, assuming the children to be exposed to such risk of dying as obtains, from one age-period to another, in a particular community. As the ages of the children advance beyond a certain limit the chance of continued survival undergoes diminution; this probability of further survival can be determined for each age. Further, the total number of years of life to be lived by persons at a particular age x, and upwards, can be predicted, and if this total number be divided by the number of persons surviving at the age x, what is called the mean after-lifetime of these persons is obtained. This mean after-lifetime, or expectation of life, can be set out in the form of a table, together with other particulars already referred to, the figures being given for each age. Such a table is called a life table.

A typical life table contains the following columns:—

(i) A column indicating the ages dealt with. Usually, annual periods are taken; sometimes the first five years of life are separately set out, and for the later years only every fifth or tenth year of age is shown.

(ii) An m_x column (sometimes indicated as the D column or M_x column). This column gives the annual mortality per unit of population at the centre of each year, or, as it is sometimes termed, the central death-rate of the year. Thus, m_x is the central death-rate of the year beginning on the completion of x years of age, and m_{10} is

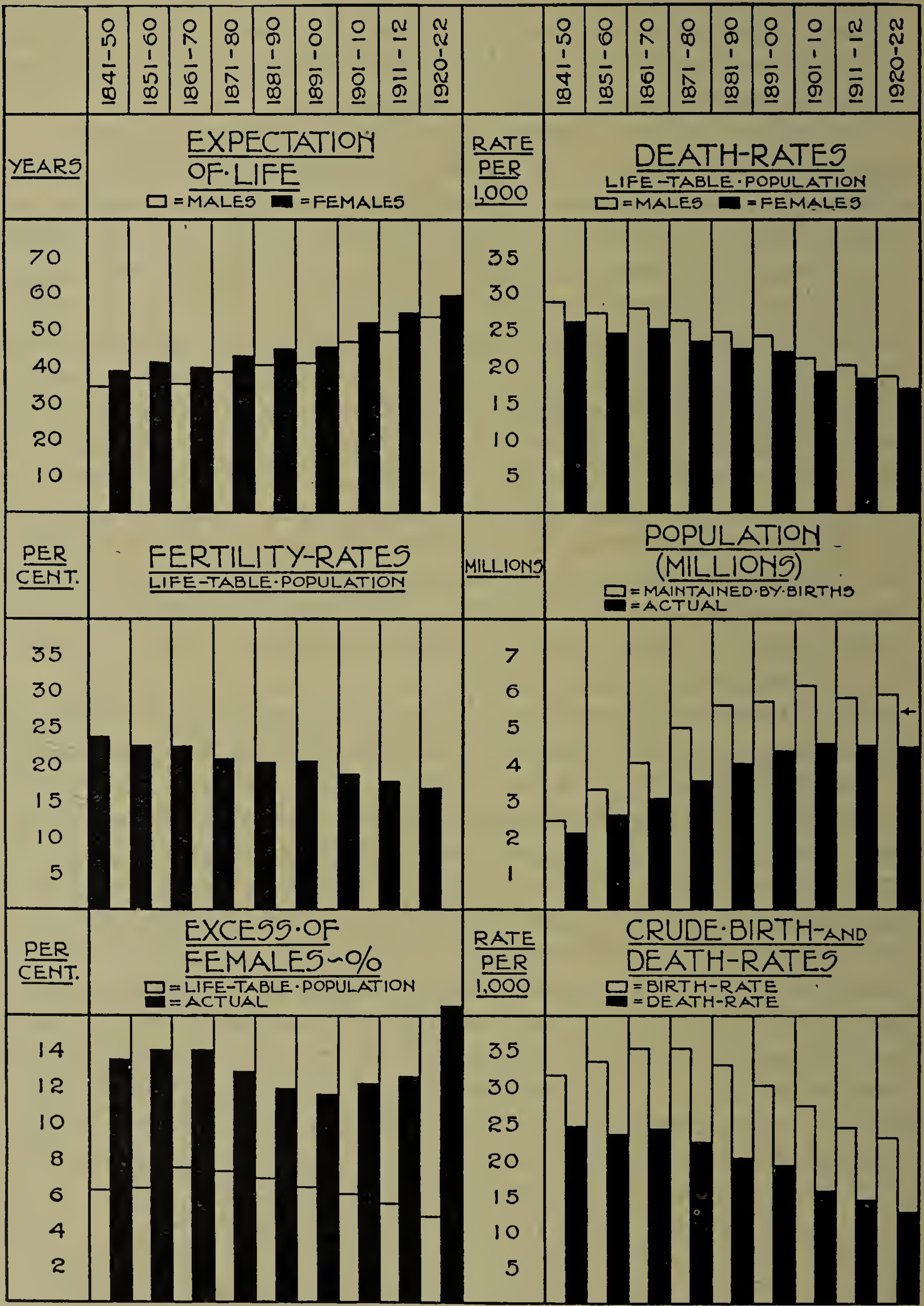

FIG. 90.—Some changes in the conditions of life as shown in the London Life Tables, 1841–1922. (*Spear.*)

the rate of mortality per unit of population at the centre of the year beginning on completion of 10 years of age, or, in the case of a million children, all born at the same time, the death-rate at $10\frac{1}{2}$ years of age.

(iii) A p_x column. This column gives the probability of living one year from the age x.

(iv) An l_x column, which shows the number of children who may be expected to survive at the precise age x.

(v) A P_x column, which shows the mean population in each year of age. Thus $P_x = \frac{l_x + l_{x+1}}{2}$[1], and $P_{10} = \frac{l_{10} + l_{11}}{2}$.

(vi) A Q_x column, which shows the years of life lived at age x and upwards. The number corresponding to any age in this column, is the sum of all the numbers in the P_x column of an extended table from that age to the end of the table.

(vii) An E_x (or e_x) column, which shows for each age the value of $\frac{Q_x}{l_x}$, *i.e.*, $\frac{\text{The total number of years lived at age } x \text{ and upwards}}{\text{Number of survivors at age } x}$. This value, E_x, represents the mean after-lifetime, or expectation of life, at each age x.

The number (Q_x, or ΣP_x) of years lived at age x and upwards, it should be noted, may be also calculated from the figures given in the l_x column; for the total number of years lived includes the sum of the complete years lived at each age $x + 1$, $x + 2$, etc., to the last age in the table (Σl_{x+1}), together with the sum of the portions of lifetime lived by each person in the year of his death. It may be assumed that the duration of life in the year of death is, on an average, half a year. Hence to the expression $\frac{\Sigma l_{x+1}}{l_x}$ the "curtate expectation of life" it is necessary to add half a year, in order to obtain the "complete expectation of life." To distinguish these expressions $\frac{\Sigma l_{x+1}}{l_x}$ is sometimes written e_x, and the complete expectation of life $\frac{\Sigma l_{x+1}}{l_x} + \frac{1}{2}$, or $\frac{\Sigma P_x}{l_x}$ is written e°_x.

In further illustration, the headings and entries for certain sample years (the intermediate years being omitted) in Farr's English Life Table No. 3 for males may be quoted:—

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[1] Another formula is usually employed to calculate P_0 owing to the large error introduced by the assumption of an equal distribution of the deaths occurring between ages 0 and 1, *viz.*:—

$$P_0 = \tfrac{1}{6} \text{ deaths aged 0–1} + \tfrac{2}{3} \text{ deaths aged 6–12 months} + l_1.$$

Age x.	Annual Mortality per Unit at age x. D or M_x.	Probability of Living one Year from each Age. p_x.	Number born and Living at each Age. l.	Mean Population in each Year of Age. P_x.	Years of Life Lived at Age x and upwards. Q_x.	Mean after-Lifetime at each Age x. E_x.
0	0·18326	0·83212	511,745	456,820	20,426,138	39·91
5	0·01369	0·98640	370,358	367,672	18,410,252	49·71
10	0·00563	0·99438	353,031	352,007	16,608,936	47·01
15	0·00519	0·99482	344,290	343,415	14,866,429	43·18
20	0·00832	0·99171	333,608	332,231	13,169,656	39·48
25	0·00920	0·99084	319,442	317,892	11,536,677	36·12
35	0·01105	0·98901	288,850	287,229	8,492,601	29·40
45	0·01554	0·98458	253,708	251,763	5,774,489	22·76
55	0·02485	0·97644	209,539	206,984	3,447,708	16·45
65	0·04698	0·95410	150,754	147,315	1,631,508	10·82
75	0·10391	0·90122	75,777	72,012	491,685	6·49
85	0·21966	0·80208	16,877	15,151	63,030	3·73
95	0·42035	0·65265	833	678	1,806	2·17
105	—	—	4	3	5	—

The construction of a complete life table for each year of age is a very laborious piece of work. It is, of course, impossible to observe a million children, and to follow them through life, though the Institute of Actuaries H^M (Healthy Males) Table is in part, it may be noted, based upon the principle of following the history of individual lives, in this case insured lives, from the date of their insurance until death. The plan usually adopted, however, is to calculate from census data the number of lives at risk, at each group of ages, and to apply to these the deaths recorded as having occurred at those ages. By this means the rate of mortality per unit of population, the central death-rate (m_x), can be determined for each age-period. By making use of these rates the life table can be constructed.

Thus, if the rate for any age be expressed per 1,000, and called D, and if the D deaths be assumed to be evenly distributed over the age-period, so that half occur in the first portion of the period, and half in the second portion, then clearly the ratio of the final to the initial population $= \dfrac{1{,}000 - \frac{1}{2}D}{1{,}000 + \frac{1}{2}D}$; for every 1,000 at the centre of the period, must represent $1{,}000 + \frac{1}{2}D$ at the commencement of the period, and must be reduced to $1{,}000 - \frac{1}{2}D$ at the end of the period.

$$\text{Thus } \frac{l_{x+1}}{l_x} = \frac{1{,}000 - \frac{1}{2}D}{1{,}000 + \frac{1}{2}D}$$

and $\dfrac{l_{x+1}}{l_x}$ = the probability of surviving one year $= p_x$.

Given the values of D (or m_x), then, for each age-period after the first (for the first year the infant mortality per 1,000 births is applied) the values of p_x, l_x, P_x, Q_x, and E_x can be worked out, and the columns of the life table filled in. For example, suppose the infant mortality to be 150 per 1,000 births, so that 1,000,000 children are reduced during the first year of life to 850,000. Suppose now the death-rate in the second year of life to be 50 per 1,000. Applying the formula, $\frac{l_2}{l_1} = \frac{1,000 - 25}{1,000 + 25}$, and it will be found that the 850,000 children are reduced at the end of the second year to 808,536.

Similarly the survivors at the end of the third, etc., years can be determined. After the first five years (if it be proposed to proceed further by quinquennial periods, adopting what is known as Farr's short method) the rate for the whole period is assumed to hold good for each of the five years.

For the determination of the values of D (or m_x) Farr used, in his English Life Table No. 1, the census returns of 1841 and the deaths

	England and Wales.	London.	Manchester.	Brighton.
		MALES.		
0	51·14	49·48	44·17	54·10
5	57·02	55·30	52·32	57·25
10	52·96	51·25	48·38	53·11
15	48·44	46·77	43·98	48·44
20	44·11	42·38	39·81	43·91
25	38·89	38·11	35·64	39·53
35	31·60	29·87	27·67	31·44
45	23·82	22·48	20·49	24·09
55	16·79	15·97	14·26	17·01
65	10·89	10·55	9·29	11·21
75	6·38	6·21	5·61	6·63
85	3·58	3·64	3·50	3·94
		FEMALES.		
0	55·00	54·49	49·00	58·68
5	59·82	59·69	55·99	61·69
10	55·80	55·64	52·18	57·26
15	51·33	51·17	47·78	52·73
20	46·99	46·74	43·57	48·34
25	42·71	42·31	39·34	43·99
35	34·25	33·72	30·90	35·16
45	26·21	25·83	23·20	27·11
55	18·74	18·65	16·34	19·77
65	12·23	12·31	10·54	12·95
75	7·21	7·26	6·46	7·27
85	4·03	3·91	4·04	4·36

of the same year. To base a life table upon the deaths of a single year is, however, open to serious objection, and, in the English Life Table No. 2, Farr employed the census enumerations of 1831 and 1841 and the deaths of seven years (the three years preceding 1841, the year 1841, and the three years succeeding 1841). The English Life Table No. 3 was based on the census enumerations of 1841 and 1851, and upon the deaths registered in the seventeen years 1838–54. Ogle constructed an English Life Table on the basis of the figures of the decennium 1871–80, and Tatham utilised for the like purpose the figures of 1881–90.

Farr, moreover, constructed a Healthy Districts Life Table on the basis of the mortality (during 1849–53) in sixty-three selected districts, and Tatham prepared a Healthy Districts Life Table, based on a larger population and on the mortality returns of 1881–90.[1]

The table on previous page gives the expectation of life at certain ages, and for each sex, in England and Wales, London, Manchester and Brighton, based on the figures of 1910–12.

Life Capital—The aggregate future lifetime of an existing population the numbers of which, in groups of ages, are known at a particular time, can be estimated by applying to it the life table figures. This aggregate future lifetime has been termed by Tatham the Life Capital of the community. The future lifetime of P_x persons living between the ages x and $x + 1$ is $Q_x - \frac{P_x}{2}$ (the mean expectation of life of each being $\frac{Q_x}{P_x} - \frac{1}{2}$), and the future lifetime of ΣP_x persons is $\Sigma Q_x - \frac{1}{2} \Sigma P_x$. The improvement brought about in health conditions in a community, as testified by lessened death-rates, and by improved expectation of life, may be also expressed in terms of gain of Life Capital. It is clear, moreover, that—

$$\frac{\text{Life Capital}}{\text{Population}} = \text{the average life capital, or future lifetime, of each member of the population,}$$

and that—

$$\text{Proportion per cent. of life capital expended in a year} = \frac{\text{Years of life expended in a year} + 100}{\text{Life capital}} = \frac{\text{Mean population} \times 100}{\text{Life capital.}}$$

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[1] The matter is further discussed in Newsholme's "Elements of Vital Statistics." Much turns on the accuracy with which the age is stated; this is especially important as regards survivors at the extreme ages.

Tests of Longevity—The distinction between certain terms often used in connection with the measurement of the duration of life needs to be borne in mind. The *mean after-lifetime*, or *expectation of life*, has already been defined. The "*mean duration of life at birth*" is identical with the mean after-lifetime, and with the expectation of life; the "mean duration of life" for any later age, if the term is used at all, would signify the age in question plus the mean after-lifetime at that age.

The "*probable duration of life*" is the age at which, as ascertained from a life table, exactly half any given number of children born will have died. The table on p. 587 shows that the probable duration of life for males (on 1881–90 figures) is 51–52, and for females 55 years. The mean duration of life differs from the probable duration of life, as Whitelegge points out, "just as the arithmetical mean of a list of numbers differs from the middle value of the series. The fact that one term has as many terms above as below it does not render it the mean of the series."

The "*mean age at death*" is obtained by dividing the sum of the ages at death by the number of deaths; it is a very rough test of length of life, and its use is a fruitful source of misconception. It depends largely upon age-distribution, and is much affected by the birth-rate. Thus, in comparing one nation with another, the mean age at death is a very unsafe test of relative healthiness. The fallacies attendant upon the use of the mean age at death are most apparent when particular groups of population, such as those following certain professions, etc., are dealt with. Thus, as Farr remarked: "It has been somewhere stated that the mean age at death of dressmakers is exceedingly low, and this has been adduced as a proof of the destructive nature of their employment. If the inquiries had been extended to boarding-schools, or to the boys at Christ's Hospital, the mean age at death would have been found still lower."

Again, in the same connection, Farr wrote: "If it were found, upon an inquiry into the health of the officers of the Army on full pay, that the mean age at death of cornets, ensigns, and second lieutenants was 22 years; of lieutenants, 29 years; of captains, 37 years; of majors, 44 years; of lieutenant-colonels, 48 years; of general officers, ages still further advanced; and that the ages of curates, rectors, and bishops; of barristers of seven years' standing, leading counsel, and venerable judges differed to an equal or greater extent, a strong case may no doubt be made out on behalf of those young but early dying cornets, curates, and juvenile barristers whose mean age at death was under 30. It would be almost necessary to make them generals, bishops, and judges—for the sake of their health."

The *number living out of which one dies annually* is sometimes referred to in connection with tests of longevity. In a stationary population, unaffected by migration, and in which the births counterbalance the deaths, the number living out of which one dies annually is equal to the mean age at death, and to the expectation of life at birth. Thus Farr, writing in the Fifth Annual Report, says: “The duration of life in England is 41 years; if the population were *stationary*, the mean age of those who died would be 41 years; and 1 in 41 would die every year. The population has, however, increased 1·41 per cent. annually during the last 40 years, and we find that the mean age of the persons who died in the year 1841, instead of being 41, is 29 years; while 1 in 46 of the population died.”

Newsholme expresses the relationship existing between certain of the terms above used by saying that “in a stationary or life-table population the following represent identical quantities:—

Mean age at death of persons at all ages

$$= \frac{\text{Sum of ages at death}}{\text{Total number of deaths}}$$

$$= \frac{\text{Number of population}}{\text{Number of deaths in one year}}$$

$$\left.\begin{array}{l} = \text{Mean duration of life} \\ \text{or Mean expectation of life} \\ \text{or Mean after-lifetime} \end{array}\right\} \text{at birth.”}$$

Bristowe obtained a formula, which is usually known by his name, by studying the hypothetical case—in which the births exceed the deaths (the ratio of both births and deaths remaining, however, uniform from year to year), in which no emigration or immigration is supposed to occur, and in which every individual born is supposed to die on attaining the mean age.

If b be the birth-rate, d the death-rate, and r the annual increase per unit of population, $r = b - d$. The unit of population becomes in the n^{th} year $(1 + r)^{n-1}$, and in that year the births are $b\ (1 + r)^{n-1}$, and the deaths $d\ (1 + r)^{n-1}$. Hence, by hypothesis, if the value of $n - 1$ be found, which makes $d\ (1 + r)^{n-1} = b$, that value of $n - 1$ will be the mean age at death,

i.e., $(n - 1) \log (1 + r) = \log b - \log d$,

$$\text{and mean age at death} = \frac{\log b - \log d}{\log (1 + r)}.$$

The formula is based on a purely hypothetical case, but it is of interest as throwing light on the extent to which the birth-rate as well as the death-rate influences the mean age at death in a population which is not stationary.

A rough formula which gives approximate results for ages between 25 and 75 is that of Willich, which puts the expectation of life, at age x, at $\frac{2}{3}\ (80 - x)$. Farr's rough approximation to the expectation of life is arrived at by adding $\frac{2}{3}^{\text{rds}}$ of the reciprocal of the death-rate per unit of population to $\frac{1}{3}$rd of the reciprocal of the birth-rate per unit of population.

Means and Averages—Value of a Mean Result—Means are of various kinds. If four quantities (a, b, c, d) be considered,

the arithmetic mean or simple average $= \frac{a+b+c+d}{4}$,

the geometric mean $= \sqrt[4]{a\ b\ c\ d}$,

the harmonic mean $= \frac{4}{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}$,

the quadratic mean $= \sqrt{\frac{a^2+b^2+c^2+d^2}{4}}$.

When the terms of a series are equal the means of various kinds are all equal; otherwise the quadratic mean is highest, then the arithmetic, the geometric, and the harmonic means follow in the order named. The arithmetic mean is that usually employed; the use of the geometric mean has already been illustrated in connection with the estimation of populations.

In *Buchan and Mitchell's Method* each term is expressed as a percentage of the arithmetic mean of the series, and a line is plotted out representing percentage excess above and deficiency below the mean. The method is convenient, as it secures uniformity of scale in comparing curves representing widely divergent or unlike quantities. It will be found that the best way of forming precise ideas as regards the utility of the method, is to undertake the labour of marking out a series of figures to scale on ruled paper, first on the ordinary system, and then on Buchan and Mitchell's method, and then make careful comparison of the charts thus obtained.

Bloxam's Method is sometimes employed when a curve has to be constructed from scanty data, and it is desirable to avoid great irregularity. For each term the mean of three adjoining terms is substituted. Thus, instead of a series a, b, c, d, etc., the terms $\frac{a+b+c}{3}$ $\frac{b+c+d}{3}$, etc., are graphically represented.

Question may arise as to the extent to which reliance can be placed upon a mean result, and the general law of error can be applied in such cases. The *probable error* giving "the limits within which it is as likely as not that the truth will fall" is obtained as follows (Jevons):—

1. Draw the mean of all the observed results.

2. Find the excess or defect, that is, the error of each result from the mean.
3. Square each of these reputed errors.
4. Add together all these squares of the errors.
5. Divide this total by the number of results.
6. Take square root of result.
7. Multiply the quotient by ·67449 (or approximately ·674 or even ·67), a natural constant number derived from the law of error in a manner which is described in mathematical works upon the subject.

Thus, merely for the purpose of illustration, taking four weekly death-rates (32, 29, 20, and 19), and applying the above rules, the "probable error" works out at about 4. Thus, it may be said, "the probability is one-half, or the odds are equal, that the true death-rate (the mean being 25) lies between 21 and 29. In actual working, of course, "many more observations than four would be necessary to make such a calculation of any 'probable error'; but the above example may serve to show the untrustworthiness of weekly death-rates as a test of sanitary condition." To obtain more and more precise results the number of observations should be further and further extended. The mathematical rule may be expressed by saying that the error diminishes as the square root of the number of observations; hence, if 1,000 observations have been collected, in order to obtain a result twice as accurate, four times the number of facts must be brought together.

What is known as *Poisson's formula* is sometimes used to determine the sufficiency of a particular set of statistical data to bear having rates calculated upon them. Thus, if there are μ observations, of which m fall in one category, and n in others (*e.g.*, out of 100 cases of enteric fever, 15 deaths and 85 recoveries occur), Poisson's rule is to the effect that the true proportion of the m category to the total μ lies between

$$\frac{m}{\mu} + 2\sqrt{\frac{2mn}{\mu^3}} \text{ and } \frac{m}{\mu} - 2\sqrt{\frac{2mn}{\mu^3}};$$

or, that the possible error of excess or defect amounts to $2\sqrt{\frac{2mn}{\mu^3}}$

In the case of the 15 per cent. case-mortality from typhoid fever, therefore, the possible error of excess or defect $= 2\sqrt{\frac{2 \times 15 \times 85}{100^3}}$

$= 10$ per cent. nearly.

The range of possible values is, therefore, from 5 per cent. up to 25 per cent. case-mortality.

Correlation—Francis Galton in his "Natural Inheritance" showed that the law of Frequency of Error could be applied with great advantage to the elucidation of certain problems suggested by the study of hereditary processes. His methods have been extended and developed by Karl Pearson and others who have applied the theory of correlation to the investigation of questions arising in connection with the theory of evolution. Like organs of the same individual resemble one another more closely than they resemble similar organs in another individual of the same race. Thus, to quote examples given by Pearson, "capsules on the same poppy plant are more alike to each other than they are to the capsules of a second plant, or the leaves of one beech tree to each other than to those of a second beech tree." This resemblance is a particular case of correlation, and the numerical theory of correlation affords a means of measuring quantitatively the degree of resemblance. Pearson has demonstrated the importance of looking upon "an organism or form of life as quantitatively described by the numerical values of the types and variabilities of its several organs, and by their inter-relationships as expressed by the coefficients of correlation." When the correlation is very high the correlation coefficient is nearly unity; if there be no correlation at all, the coefficient becomes zero. The correlation coefficients in man, of right and left femur (·96), first joints of right-hand index and little fingers (·82), etc., etc., have been determined. (See table, p. 402, "The Grammar of Science.")

In the questions of interest in preventive medicine the characters dealt with do not, as a rule, admit of quantitative measurement; thus, in vaccination, the presence or absence of a cicatrix is noted, but the data necessary for classification of cicatrices, after the manner adopted in dealing, for example, with lengths of bones, may not be available. G. Udny Yule, in a paper entitled "On the Association of Attributes in Statistics" ("Phil. Trans.," Vol. 194, pp. 257–319), has referred to the "need of a *coefficient of association* to take the place of the *coefficient of correlation* for continuous variables, and be a measure of the approach of association towards complete independence on the one hand and complete association on the other." Having selected a form of coefficient which satisfies certain necessary conditions, he illustrates its use by investigating the association between non-vaccination and attack in infected households. He employs the table given on p. 65 of the Final Report of the Vaccination Commission, which gives particulars as to vaccination and attack, in children under 10 and persons over 10, in outbreaks of small-pox in five towns, and finds that—"The association between non-vaccination and attack is very high indeed for young children, ·8 to ·9, but drops sharply to ·5 (owing, presumably, to the waning protection of the vaccination made in infancy) in the older age group."

In a paper "On the Correlation of Characters not Quantitatively Measurable" ("Phil. Trans.," Vol. 195, pp. 1–47), Pearson has referred to "the correlation between strength to resist small-pox and the degree of effective vaccination." Dealing with the statistics of the Metropolitan Asylums Board for the epidemic of 1893, he obtains the coefficient ·5954 (with probable error ·0272), and hence concludes that there is "quite a large correlation between recovery and the presence of the cicatrix." He adds that, "while the correlation is very substantial," it is "perhaps smaller than some over-ardent supporters of vaccination would have led us to believe." He also applies his method to the question of the effectiveness of the antitoxin treatment, and obtains coefficients which are "sensible as compared with their probable errors," but "the relationship is by no means so great as in the case of vaccination."

Cancer—Of late years this disease has received a great deal more attention than was the case at an earlier period. Cancer statistics were until recent years very imperfect and knowledge of its prevalence and of its geographical distribution at the present day is far from precise; the interpretation even of such statistical records as are available has been rendered especially difficult by looseness of terminology, and by the fact that malignant disease not infrequently affects internal organs, and hence, in the absence of post-mortem examination, has, no doubt, been in numerous instances altogether overlooked. Having regard to these considerations, it is not surprising that the recorded cancer mortality has notably increased in recent times; indeed, comparison of registered mortality fifty or sixty years ago (1861–70), with the registered mortality nowadays, shows that the deaths per million living in this country have practically trebled.

The following table (abstracted from one given by Newman) exhibits the rates per million living at all ages standardised, and at ages over 45, since 1871:

Period.	All ages standardised.	45–	55–	65–	75 and upwards.
Males—					
1871–80	333	706	1,593	2,605	2,989
1881–90	465	1,002	2,302	3,758	3,926
1891–1900	639	1,300	3,160	5,325	5,824
1901–10	784	1,549	3,904	6,683	7,874
1911–20	936	1,753	4,504	8,168	10,140
Females—					
1871–80	619	1,764	2,765	3,524	3,520
1881–90	739	2,051	3,375	4,531	4,601
1891–1900	882	2,323	4,099	5,829	6,377
1901–10	942	2,321	4,410	6,658	7,901
1911–20	996	2,348	4,623	7,341	9,739

The increase is much more marked in males than in females. While about as many deaths, per million living, were recorded in males as compared with females in 1861–70, the rate in males now is very much the same as that in females.

Cancer mortality is comparatively small until the age-period 35–45 is reached; it then steadily increases with advancing years. The increase observed of late years, as compared with the decade 1861–70, is specially marked, in males, at all age-periods after and including the period 35–45; in females, the increase is less marked up to 55, but is very marked at the later age-periods.

The distribution of cancer in English counties is dealt with by the Registrar-General in the Supplement to his Fifty-fifth Annual Report (p. liii. *et seq.*). In determining the rates observed, the question of age and sex destribution exerts considerable influence. The Registrar-General has, therefore, calculated (*loc. cit.*) the cancer mortality for each county in terms of a "standard million" of population over 35 years of age; as an instance of the alteration thus brought about, it may be noted that whereas the difference between the crude rates for London and Cornwall is some 2 per cent., the difference in their corrected rates is 38 per cent. Taking the rates as corrected by the Registrar-General, those of London and Huntingdonshire were the highest, those of Wiltshire and Cornwall the lowest; the highest rate, that of London, was 2,250, the lowest, that of Cornwall, 1,630 per standard million above 35 years of age.

These facts accord with the hypothesis that the increase in cancer mortality is more apparent than real. While varying age constitution can be to a large extent allowed for, there are other difficulties to be considered. Thus in his 44th Annual Report (1881) the Registrar-General comments upon the fact that "not rarely the real cause of death is purposely disguised in order to spare the susceptibilities of friends, or it may be to conceal the existence of infectious disease." Fifty years ago this remark applied in a very special degree to cancer, which at that time was generally held to be both inherited and infectious. Over and above this there remains the question of improved diagnosis.

Newsholme and King in 1893 reached the conclusion that the increase in cancer mortality up to that time was apparent and not real. This result was deduced from data collected in the Scottish Widows Office and from certain Frankfort statistics. The former set of figures shows increased mortality from cancer; but on comparison with the curves for the English, Scotch and Irish populations generally, the Scottish Widows Office curve has "the easiest gradient." "The policy-holders in the Scottish Widows Office are presumably well-to-do, and able to secure, on the whole, better medical attendance than the mass of the people, and their death returns consequently show to a less extent the effect of increased accuracy of diagnosis and certification." Again, in Frankfort the records enable the cancer deaths to be classified as "accessible, inaccessible, and cancer of undefined position," and it transpires that "between 1860 and 1889 there has been no increase in the mortality from cancer affecting positions in which it is easily accessible and detected."

The progressive increase in the rates since 1893, and particularly in those of males at the higher ages, has led in recent years to critical re-examination of the above conclusion.

The Frankfort figures were carried down to 1913 by Willcox of Cornell University "with the result of confirming the earlier observations." Stevenson a few years later (Ann. Rep. of Reg.-Gen., 1917), analysed the figures for England and Wales classifying cancer deaths by the site affected, which were then available for 21 years. So far as females were concerned the mortality disclosed in these figures from cancer affecting "inaccessible" positions exceeded that for "accessible" positions, as had been the case throughout in Frankfort. But in males the results were "quite unexpected," for the percentage increases in "accessible" positions exceeded those in "inaccessible" positions. Stevenson's classification of sites as "accessible" or "inaccessible" was—with an exception as regards 'bones (jaw excepted),' which he notes—"based upon the results of an inquiry made by the Bureau of the United States Census." He draws attention to the fact that in his Tables (following the practice of the American inquiry) the rectum and larynx were classed as "accessible" sites; it appears, moreover (from Table LIX), that if the rectum and larynx had been classed as "inaccessible," the unexpected result in males would have been materially affected. He notes that, if the conclusion suggested (by increase in the "accessible" rates in males) be accepted, it has to be admitted that the evidence is less convincing in the case of females, though "even with them there is not the complete absence of increase in mortality from 'accessible' cancer which the Frankfort figures show." The Ministry of Health Circular of August, 1923, points out, however, that "superficial cancers such as those of the tongue or the female breast were readily recognisable as such 60 years ago by the time death occurred, and that recorded increases of 39 and 28 per cent. respectively have occurred in male rates for the tongue and female rates for the breast during the period 1901–21. The whole subject demands further inquiry especially in the light of international statistics; Newman notes (1923) that study of national differences in the mortality from cancer of certain regions of the body was then being undertaken. It has been suggested that, inasmuch as more people nowadays survive and reach those age-periods at which cancer mortality is especially marked, it is to be anticipated that the deaths from cancer would show increase. This is doubtless true, but it does not account for the whole of the increase observed.

The view that cancer is an inherited disease was at one time generally accepted. The Registrar-General, in his Fifty-second Annual Report, p. xiv., pointed out, however, how considerable was the probability of multiple occurrences of cancer among the near relatives of a given individual, having regard to the fact that it appeared, from the figures of 1887–89, that one out of twenty-one men, and one out of twelve women, who reach the age of 35, die eventually of cancerous disease. The Registrar-General's conclusions on this matter have been generally accepted; but, curiously enough, a new doctrine, which from a statistical standpoint appears to be equally groundless, has latterly obtained some credence.

Behla first drew attention to the frequency of occurrence of multiple cases of cancer in one and the same house. If the scope of the inquiry be sufficiently extended, "cancer houses," as Behla terms them, are not, as a rule, hard to find. Symons, however, showed that the statistics of Bath proved these multiple invasions of houses by cancer to be actually less frequent than might have been anticipated as a matter of pure chance. Niven, in the annual report for Manchester, 1897, discusses the mathematical treatment of this question of multiple invasions of houses. He shows that if $x = \frac{\text{Average number of houses affected}}{\text{Average number of occupied houses}}$, and m be the number of years over which the inquiry extends; then the chance of any house being invaded twice $= \frac{x^2 m\ (m - 1)}{1 \cdot 2}$, and the chance of triple invasion $= \frac{x^3 m\ (m - 1)\ (m - 2)}{1 \cdot 2 \cdot 3}$. Hence the number of double invasions must be $\frac{x^2 m\ m - 1)}{1 \cdot 2} \times$ the total number of occupied houses; and the number of triple invasions must be $\frac{x^3 m\ (m - 1)\ (m - 2)}{1 \cdot 2 \cdot 3} \times$ the total number of occupied houses.

Applying these formulæ to Behla's figures, the number of multiple invasions proves (as Symons had already found to be the case at Bath) to be rather smaller than might have been predicted, assuming the question to be merely one of casual coincidence. Remarkable cancer sequences have been recorded—cases in which successive occupants of particular rooms, persons who visited from time to time particular localities, and so on, have succumbed to cancer. The instances cited have so far served merely to show how little attention is commonly given to the question of the probability, *a priori*, of a particular sequence of events occurring. With further study of cancer sequences and cancer localities, it is possible that knowledge concerning such matters may be advanced ; due regard must, of course, however, be paid to the fact that, inasmuch as the disease is an exceedingly common one, the chance of occurrence of these so-called " notable sequences " is necessarily considerable.

Cancer has been extensively studied from the point of view of its inoculability in lower animals. It has been claimed that some forms of blastomycetes, or again that protozoa, are concerned in the production of cancer. Gye and Barnard maintain that an ultravisible virus and an activating chemical substance are responsible for cancer. (See "Lancet," July 18, 1925.)

Chimney-sweeps in this country are especially liable to cancer of the scrotum and skin. This is due to contact with soot. Abroad, where by using different methods or by more frequent washing the contact with soot is lessened, chimneysweeps' cancer is rare. In Belgium, for example, where coal like English coal is used, there is almost complete immunity, but great care is taken to prevent contact with soot. Gardeners who are in the habit of sprinkling soot upon plants to protect them from slugs occasionally develop epitheliomatous ulcers of the hand. Men breaking up pitch suffer from pitch warts on the hands and arms and these in some cases become epitheliomatous. Workers making briquettes with coal dust and pitch are more exposed to the action of the pitch ; they suffer to a greater extent from pitch warts and epithelioma.

Cancer of the skin known as paraffin cancer occurs among the shale oil workers in Scotland, and cancer of the scrotum among mule spinners ; the clothing of these workers near the groin becomes impregnated with mineral oil derived from the machine.

Recently the Home Office has made tar cancer notifiable as an industrial disease in England and Wales, and in 1920 forty-five cases were recorded, with one death. Of these thirty-three were due to pitch, nine to tar (net fixing, repairing barges, tar distilling, purification of anthracite, gas workers), and three to paraffin. The fatal case occurred in a man employed as a stoker in a gas works.

Other coal tar products have been held to cause cancer ; thus where aniline, naphthylamine and their homologues and benzidine are made, the workers have been found to suffer from papillomatous growths of the bladder. The greater prevalence in males than females of cancer of the buccal cavity also falls into line here, since it may be due to the male habit of smoking which exposes this part of the body to the products of distillation not of coal, but of other vegetable matter in the form of tobacco.

These instances are sufficient to suggest that the products of vegetable distillation have a traumatic action on the tissues, which determines the incidence of cancer in the organ or part of the body exposed to their influence.

Other instances of cancer definitely recognised as being determined by trauma are Röntgen-ray cancer among X-ray operators which affects the part exposed to the light rays, cancer of the cheek among the natives of Ceylon due to their habit of chewing betel nut, and cancer of the skin of the abdomen, Kangri cancer, among natives of Afghanistan, due to burns caused by wearing charcoal stoves for the sake of warmth.

Apparently meteorological conditions have no influence on the incidence of cancer. Maynard found no connection between the number of hours of sunshine, mean temperature and rainfall and the cancer death-rate in certain large towns in the U.S.A.

The Ministry of Health Circular of August, 1923, states, *inter alia*—"An increase of mortality attributed to cancer is the common experience of modern civilisation"—"The most rapid increase is occurring in extreme old age"—"There is no evidence to show that cancer is an infectious or contagious disease"—"This liability of cancer to follow chronic irritation of so many different types is remarkable and leads to the supposition that beneath them all lies some common factor—as yet unrecognised—which is fundamental to the passage of a chronic inflammatory and non-cancerous condition into one that is definitely cancerous"—"Early diagnosis is of the greatest importance"—"The chances of a patient must be better the earlier he or she comes under treatment"—"In any condition in which cancer is suspected immediate and decisive action is necessary."

The attention of local authorities is specially directed to such questions as the following :—

"(1) Improving the local facilities for clinical consultations and for pathological examinations;

(2) Improving the local facilities for cancer treatment (operative or provision of X-ray and radium apparatus) and considering the adequacy of arrangements for this purpose at hospitals, local institutions, etc., which serve the area;

(3) Improving the facilities for transport of patients;

(4) Arranging locally for postgraduate demonstrations; lectures, or courses on cancer for medical men practising in the area;

(5) Arranging locally for the education of the public (by leaflets, etc.)."

Emphasis is laid on the need to avoid "over-statement, the making of promises which are not warranted by evidence, or the production of needless and mischievous apprehension of cancer."

CHAPTER XII

MATERNITY AND CHILD WELFARE

FŒTAL AND INFANTILE MORTALITY

THE interest which used to be concentrated on infantile mortality has now been spread over the earlier as well as the later phases of the problem.

Attention was drawn to the number of children who died within a few days of birth ; these included a number of feeble, malnourished or premature children, half of whom die in the first twenty-four hours of life. Clearly the deaths of these children could not be ascribed to conditions arising after birth ; they were due to some cause acting before birth. Interest in antenatal hygiene was aroused ; consideration of the relative importance of antenatal hygiene and proper care during labour brought out the necessity of making adequate provision for cases of difficult labour.

Before the problem of the saving of fœtal life can be tackled its extent must be ascertained.

From the compulsory notification of stillbirths (after the twenty-eighth week of fœtal life) we know that the average number during the last twelve weeks of gestation in England and Wales is 30 per 1,000 births, and statistics collected point to the probability that miscarriages between conception and the twenty-eighth week are about four times as many. If these estimates of miscarriages be correct, it means that there are 150 deaths of the fertilised ovum and maturer fœtus during pregnancy for every 1,000 births, in other words that 1,150 pregnancies result in 1,000 live births.

Statistics point to at least a doubled stillbirth rate in unmarried mothers, and there is strong evidence that, including criminal abortion, the rate of miscarriages is also about double in illegitimate cases.

The term " abortion " is often applied to premature expulsion of the ovum from the uterus in the first two or three months of pregnancy before the placenta is formed, later, after the placenta is formed, up to the date when the child is viable, the term " miscarriage " is used. Any premature expulsion of the ovum before the twenty-eighth week of pregnancy should however be termed an " abortion."

Abortions—Both the excitability of the nerve centres and the congestion of the uterus are greatest at the times which would have been menstrual periods if pregnancy had not occurred, and hence abortion is especially likely to happen at these dates. Women vary very considerably in the ease with which abortion can be excited. The difference depends chiefly on the irritability of the nervous system, but also to some extent on the firmness of attachment of the ovum to the uterus. The attachment is less firm before the complete formation of the placenta in the early months of pregnancy ; hence abortions are most common in the first four months of pregnancy, especially the third month. The causes of abortion may be divided (1) into those which affect the ovum, (2) the uterus, and (3) those which affect the mother directly.

Of the first division the sub-divisions are :—

(i) All diseased conditions of the fœtus, especially those resulting in its death : even disease or malnutrition of the fœtus not sufficient to cause death may lead to abortion.

Among the causes leading to the death or malnutrition of the fœtus must be included imperfect fertility on the part of either or both parents.

(ii) Diseases, of the amnion, including amniotic adhesions to the fœtus, chorion (especially hydatidiform degeneration, or decidua (especially chronic endometritis), either causing death of the fœtus or irritation of the uterus.

Of special importance are the unhealthy conditions which lead to hæmorrhage and consequent separation of chorion and placenta ; hæmorrhages into and of the placenta and white infarcts are also frequent causes. Separation of the placenta and hæmorrhage often arise from mechanical causes, especially in cases of placenta prævia. Among these may be mentioned blows, violent muscular exertion, the effect of coughing, vomiting or straining at stool, and the use of instruments for the induction of criminal abortion.

Unhealthy conditions of the uterus responsible for abortion include displacement, especially backward displacement, fixation of the uterus by peritoneal adhesions, or the presence of fibroid or other tumours.

As regards causes affecting the mother directly, if there is a predisposition to abort, certain drugs especially ergot, quinine in large doses, and also savin and cantharides may cause abortion.

All acute febrile diseases, especially small-pox and pneumonia, tend to cause abortion. Imperfect aeration of the blood resulting from asphyxia, whether due to mechanical obstruction or heart or lung diseases, and the poison which exists in the blood in renal disease often bring about abortion. Lead poisoning even in the father is often responsible.

Any grave disease of the mother is likely to cause abortion, also such troubles as extreme malnutrition or excessive vomiting of pregnancy and other general states of the system, such as heart disease or cirrhosis of the liver.

Causes of abortion acting through the nervous system include emotion such as fright, grief, anxiety, shock such as having bad news, or seeing some startling sight, especially in women of highly sensitive and neurotic disposition. Abortion also results from such stimulation of nerves as is caused by a baby suckling, or severe pain from toothache, tooth extraction, violent purgatives or operations, or mechanical interference such as vaginal syringing in the neighbourhood of the pregnant uterus.

For habitual abortion syphilis is often responsible. Chronic endometritis and retroversion are the most important local, and kidney disease, diabetes, and chronic lead poisoning[1] the most important general causes.

Stillbirths—The body of a fœtus that dies during the antenatal period is usually born in a macerated condition ; the body of a fœtus dying shortly before birth or during birth is in a fresh condition. Out of every 100 cases of stillbirth about 60 of the bodies are fresh and 40 macerated ; roughly, therefore, about 60 per cent. of fœtal mortality is due to the accidents and complications of labour.

Eardley Holland considers that the causes of death of macerated fœtuses are approximately as follows :—Syphilis (34 per cent.), toxæmia of pregnancy (20 per cent.), relative placental insufficiency from abnormal smallness of the placenta, or excessive infarction and separation of the placenta by retro-placental hæmorrhages (20 per cent.) and chronic renal and other maternal diseases, severe fœtal deformities such as anencephaly, hydrocephaly, and œdematous states of the fœtus (6 per cent.), and to undetermined causes must be ascribed 20 per cent.

The cause of death of the fresh fœtus include placenta prævia, accidental hæmorrhage, instrumental or natural delivery through a contracted pelvis, breech presentation, delivery by version, prolapse of the cord, and delayed labour from any cause, and especially severe injury to the head caused during labour, which accounts for half of the deaths.

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[1] To prevent the use of diachylon, the commonest form of lead taken, for the purpose of procuring abortion, the Privy Council issued an order of the 27th April, 1917, by which lead in combination with other substances whether sold as diachylon or under any other designation, except machine-spread plasters, is declared to be a poison and to be included in Part 1 of Schedule A to the Pharmacy Act.

The causes of stillbirths are given as follows :—

	Holt and Babbitt (Sloane Hospital for Women).	Beckwith Whitehouse (Birmingham Maternity Hospital).	Whitridge Williams includes deaths within first fortnight of life.
Prolonged, difficult or complicated labour	45 per cent.	69·5 per cent.	22·5 per cent.
Toxæmia of pregnancy	14 ,,	13·1 ,,	6·5 ,,
Syphilis	9 ,,	—	26·4 (35 per cent. negroes, 14 white).
(Women obviously suffering from syphilis were not admitted.)			
Prematurity. . .	4 ,,	3·6 ,,	7·1 per cent.
Inanition. . . .	—	—	3·3 ,,
Debility	—	—	·9 ,,
Criminal suffocation	—	—	·7 ,,
Malformation of fœtus	2 ,,	5·0 ,,	3·4 ,,
Unknown . . .	20 ,,	8·6 ,,	18 ,,
Various	—	—	11 ,,

The proportion of stillbirths in England and Wales is approximately 30 per 1,000 infants born.

Eardley Holland divides causes of fœtal death into :—

(i) Those the cause of which can be discovered during the antenatal period, and can be prevented by purely antenatal treatment. Syphilis, which has recently been shown by Cruickshank to be a most important cause of premature stillbirths, is the great representative of this group.

Another example is toxæmia of pregnancy, many cases of which can be kept within reasonable bounds or even cured by simple antenatal treatment. Still another example is breech presentation, for which we can perform external version.

(ii) Those which can be discovered during the antenatal period, but which depend for their prevention on special treatment during labour. The best example of this is contracted pelvis. If discovered early enough in pregnancy the obstetrical treatment can be planned and may be waiting for natural labour with the help of forceps if necessary, or induction of premature labour or Cæsarean section. Another example is afforded by those cases of toxæmia of pregnancy which do not yield to antenatal treatment, and which must be treated by the induction of premature labour.

(iii) Those the causes of which are not discoverable in the antenatal period, but which make their presence known just before or coincidently with the onset of labour or during the course of labour. Examples of this group which are prolific of fœtal death are the antepartum hæmorrhages. Other common causes are prolapse of the umbilical cord and cases of prolonged labour from such causes as persistent occipito-posterior presentations.

(iv) Those of which the causes so far as our present state of knowledge stands are not discoverable or preventable by any means whatever. These include the great group in which the cause of fœtal death cannot be determined, the cases of relative placental insufficiency, those cases in which a blood clot is found behind the placenta, and cases of severe fœtal deformity.

Beckwith Whitehouse, analysing the results at the Birmingham Maternity Hospital during the period 1910–19, gives the following analysis of pathological conditions of the mother and child in the case of 653 cases (91·4 per cent. [those in which a cause of antenatal fœtal death was assigned] of the total 715 born dead) :—

Constitutional maternal diseases—Chronic valvular disease of the heart (mitral), 11 ; other conditions, 7 ; total, 18.

Toxæmia—Eclampsia, 64 ; Albuminuria, 27 ; Hyperemesis, 3 ; total, 94.

Anomalies of placenta—Placenta prævia (31 *per cent. of total*), 205 ; Antepartum hæmorrhage, 51 ; total 256.

Anomalies of umbilical cord—Prolapse of cord, 25 ; Cord around neck, 1 ; Thrombosis of cord, 1 ; total, 27.

Obstructed labour—Obstructed labour (forceps), 85 ; Craniotomy, 50 ; Malpositions (version, etc.), 49 ; Cæsarean section, 8 ; total 192.

Anomalies of fœtus—Hydramnios, 19 ; Hydrocephalus, 6 ; Anencephalus, 7 ; Atelectasis, 1 ; Fœtal ascites, 1 ; Spina bifida, 1 ; Fœtal heart disease, 1 ; total 36.

Prematurity—Prematurity, 26 ; Premature rupture of membranes, 1 ; Twins, 2 ; Triplets, 1 ; total 30.

Recently considerable emphasis has been laid on cranial injuries and cranial stress resulting in tears of the tentorium cerebelli and the falx cerebri, and intracranial hæmorrhage as causes of infantile death during or shortly after labour [1] ; much has been made of the unnecessary use of obstetric forceps.

A premature birth is one which occurs before the thirty-eighth week of gestation. Prematurity is often due to undue physical effort or mental strain in the mother, or to malnutrition or to death of the fœtus. (Antepartum hæmorrhage and toxæmia are also responsible.)

Of the total deaths of infants during the first year of life, one-third occur during the first month of life.

Seven-eighths of the deaths occurring within the first month of life occur in the first fortnight. Statistics dealing with an ordinary population are not available. In a modern lying-in hospital which deals only with emergencies, deaths within the first fortnight of birth were investigated, and it was found that congenital weakness due to prematurity accounted for 50 per cent.

Obstructed labour and asphyxia at birth are responsible for cases of infantile hemiplegia and diplegia, many of whom are of below average mentality.

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[1] See "On the causation of fœtal death," by Eardley Holland (Ministry of Health Report, No. 7).

Antenatal care may probably lessen this proportion. Atelectasis was responsible for 8 per cent.

Conditions associated with delivery—difficult labour, persistent malpresentation, and prolonged labour causing intracranial hæmorrhage, etc., were responsible for 20 per cent. This group is associated in some measure with maternal mortality and both will be lessened by common measures, chiefly antenatal supervision and improvement of the midwifery service.

Malformations of the heart, intestine and nervous system and congenital disease such as status lymphaticus caused 4 per cent. of the deaths, asphyxia produced by laryngeal obstruction, a knot in the umbilical cord, and the twisting of the cord round the neck for others ; hæmorrhage of the new-born and sepsis in the form of general infection, phlebitis, etc., were responsible for a few deaths. Women with syphilis were not admitted to the hospital ; the mortality from congenital syphilis therefore could not be ascertained. The only important disease developing after birth was pneumonia, which was responsible for 9 per cent. of the deaths.

In 1917, 64,483 children died in England and Wales under one year of age, the infant mortality rate was 6 per 1,000 births, and 25,000 of these infants died in the first month. The causes were as follows :—

	Per Cent.
Developmental and wasting diseases	36·55
Diarrhœa and enteritis	10·30
Common infectious diseases	5·74
Tuberculosis in all forms	2·75
Bronchitis and pneumonia	19·87
All other causes	21·27

There has been a steady decline for some years past in all these groups, though there have, of course, been variations in the rise and fall of disease within the groups and they have not all declined equally. The three principal causes of the death of infants, responsible for some 70 per cent. of the total number, are prematurity, immaturity and congenital defects—due in part to poor maternal physique and disease : bronchitis and pneumonia—due to exposure to cold and to infection : diarrhœa and enteritis—due to unsatisfactory feeding or infection. In this group the decline in the mortality rate has been especially marked.

Causes of Special Decline in Infant Mortality—In most civilised countries there has been a very marked decline in infant mortality during the present century ; in England and Wales, for instance, the rate has fallen since 1900 from 154 to 69. There were indications of this improvement, in countries leading the way in sanitary progress, soon after the middle of the nineteenth century, and the exceptionally high rates of infant mortality which formerly obtained gradually disappeared as one nation after another followed the example of the pioneer countries. Paradoxically enough, however, during the last 20 years of the nineteenth century, while the death-rate at all ages in the leading countries continued to fall, infant mortality in those countries did not show a corresponding decline. It was suggested that the main reason for this phenomenon was to be sought in the lapse of time needed for the gradual education of the public and especially of the women, many of whom would become the mothers of the new generation of children. The fact has to be appreciated that some such lapse of time must occur in order to permit of the upgrowth of a generation of parents who have themselves been through the schools. This view of the question was defended in detail by Wheatley in an address before the British Medical Association in 1923. Other explanations have been forthcoming. For example, Maternity and Child Welfare work has been held to have been an important factor; but while this helps to explain the decline in infant mortality observed since 1910, it does not account for a fall which antedated that time by several years. Stress has also been laid upon such questions as increased prosperity and upon improvements in food, particularly in milk, supplies. Again, special importance has been attributed to increase in national sobriety, to the use of tarred roads and decrease of horse traffic, and the decline of the birth-rate has even been invoked. All these factors have possibly to a greater or less extent been operative, but fuller knowledge on the part of the mother is by far the most important factor inasmuch as she practically constitutes the environment of the infant. It should be noted that even under primitive conditions of living and in the face of actual poverty quite low infant mortality rates are sometimes observed when the factors of maternal care and solicitude and above all breast-feeding are not lacking.

The means of bringing about a further decrease of the death-rate among infants are improved feeding both of mother and baby, and a higher standard of maternal physique and better infant management. Among the important external causes of infant mortality are domestic insanitation in its widest sense, unsatisfactory systems of disposal of excreta and refuse, the unfavourable conditions of urban life, overcrowding, unpaved yards and streets, ineffective scavenging, poverty and filth. All these circumstances contribute, directly or indirectly, to a high death-rate among infants. The problem is not one of sanitation alone, or housing, but it is mainly a question of mothercraft and ignorance of infant care and management, which, however, in practice is found closely associated with defective sanitation, overcrowding and unsatisfactory housing conditions. Malnutrition of the mother rarely exists apart from such conditions.

The causes of infantile mortality may be summarised as follows :—

Antenatal which includes :—Early marriages, constitutional weakness on the part of the parents, including diabetes and syphilis ; poverty ; employment causing lead poisoning ; insanitary surroundings ; intemperance ; illegitimacy ; the use of abortifacients.

Intranatal :—Difficult labour.

Postnatal which include :—Structurally defective and insanitary dwellings ; overcrowding ; high birth-rate ; absence of breast-feeding, due in some instances to industrial employment of women ; improper feeding ; impure milk supply ; want of domestic cleanliness and care ; intemperance on the part of the parents, leading to poverty and neglect ; illegitimacy.

The chief remedies include :—Improved housing and sanitary surroundings ; the prevention of overcrowding ; prohibition of industrial employment of women for a certain period before and after confinement ; a purer milk supply ; systematic instruction in schools in domestic hygiene and temperance ; early notification to Sanitary Authorities of all births ; the registration of stillbirths ; the appointment of Women Health Visitors ; the suppression of advertisements relating to the procuration of abortion ; provision of skilled midwifery attendance ; provision of emergency medical assistance during pregnancy, labour and lying-in ; treatment at venereal disease centres.

Ophthalmia neonatorum is defined as " a purulent discharge from the eyes of an infant commencing within twenty-one days from the date of its birth." In about 70 per cent. of the cases the gonococcus is present in the discharge ; streptococci are responsible for most of the others. Some of the worst cases occur in babies whose mothers present no history of vaginal discharge. Within recent years the number of cases notified in England and Wales has varied from 8·35 per 1,000 births in 1915 to 12·49 in 1919, but there is good reason to believe that notification is defective. All degrees of the disease are seen ; slight cases can usually be treated at home without any permanent harm to the eyesight occurring. When admitted to hospitals the mortality of these babies is high, due in part to separation from the mother and the consequent breaking off of breast-feeding. When the mother accompanies the baby to hospital this high mortality does not occur. Rarely can severe cases receive adequate attention at home ; in hospitals the eyes are treated hourly, two-hourly or three-hourly in the daytime according to the severity of the discharge and two-hourly during the night. At the St. Paul's Eye Hospital, Liverpool, where the mother and baby are admitted into a special ward, from 1908–21 inclusive, out of 2,770 infants 91·8 per cent. were completely cured, 1·08 per cent. became blind ; the eyesight was damaged in 4·7 per cent.

Much of the disease could be prevented by the routine use of a suitable application such as argyrol (20 per cent.) or silver nitrate (1 per cent.) to the eyes of all new-born infants.

Pemphigus neonatorum, a somewhat rare contagious pustular affection, possibly due to *staphylococcus pyogenes aureus*, occurring in limited epidemics, has been observed to follow the practice of a particular midwife. In an outbreak at Richmond, Surrey, in 1902, reported by G. Maguire, eighteen infants were infected with pemphigus and eight died, an unusual mortality rate. All these cases occurred in the practice of a midwife who attended twelve of the infants at birth and washed five of the others; the remaining child was presumably infected by being laid on an infected apron after being washed by the midwife's assistant. Death was due to infection of the unhealed stump of the umbilical cord. Others in the family, both adults and children, were also affected either in consequence of washing soiled clothes, nursing infected children, or by contact. (See also Memo. $\frac{103}{\text{Med.}}$ on pemphigus neonatorum.)

Maternal Mortality—On an average in England and Wales there occur each week 67 deaths of mothers as a result of pregnancy and childbirth, of which 24 are due to puerperal infection. The maternal mortality rate for the country as a whole is equivalent to about 4 maternal deaths for every 1,000 live births, and this figure has been fairly constant for more than 20 years although considerable improvement has been effected as regards puerperal septic infection. The death-rate from this cause for every million women living in England and Wales in 1900 was 121; this number by 1923 has been reduced to 49. This marked decrease has occurred during the time Local Authorities and the Central Midwives' Board have been carrying out their duties under the Midwives Act, 1902; to their activity this saving of life can reasonably be ascribed. The deaths from other causes and accidents of childbirth have, however, remained sufficiently numerous to prevent any lowering of the average maternal mortality rate.

The maternal deaths directly due to childbearing represent only one aspect of the question. The numbers, although relatively small compared with the total deaths at all ages and from all causes, relate for the most part to young and healthy women whose death involves exceptional domestic distress. Secondly, these deaths are indicative of much suffering and ill-health among the women who survive; the genital passages are injured and the health generally affected.

Insanitary conditions appear to have less direct influence upon puerperal mortality than might be supposed; nor has employment of married women had direct influence upon the maternal death-rate, at any rate as far as the nature of the occupation is concerned, though the double strain of housework and outside employment may impose too heavy a burden upon the mother with diminution of her powers of resistance.

The deaths which occur during or subsequent to childbirth may be divided into (*a*) deaths due to hæmorrhage, antepartum, postpartum and puerperal, or to "accidents" of labour, *e.g.*, rupture or laceration of the uterus or vagina or bladder, and deaths after instrumental or operative delivery and (*b*) deaths due to sepsis. The extent of the mortality is shown in the following table :—

Average Yearly Mortality Rate for 10 Years, 1911–20, per 1,000 Live Births.	England and Wales.	Scotland.	Ireland.
Complications and accidents of pregnancy.	1·233	1·897	1·026
Puerperal convulsions and albuminurias of pregnancy . . .	0·80	0·96	0·64
Hæmorrhage and accidents of childbirth	0·995	1·446	2·081
Sepsis	1·838	1·925	2·061
Total mortality of child-bearing, including pregnancy. . . .	4·07	5·26	5·17

A more detailed analysis relating to the year 1922 shows that of 2,971 deaths the numbers due to abortion were 921 ; ectopic gestation, 86 ; other accidents of pregnancy, 132 ; puerperal hæmorrhage, 390 ; other accidents of childbirth, 304 ; puerperal sepsis, 1,079 ; phlegmasia alba dolens, not returned as septic, 54 ; puerperal embolism and sudden death, 242 ; puerperal albuminuria and convulsions, 556 ; childbirth, not assignable above (puerperal insanity), 30 ; puerperal diseases of the breast, 6.

As regards remedial measures the complications of labour should be taken seriously by public and hospital authorities and the public generally. The provision of midwifery beds in maternity hospitals and general hospitals must be adequate ; this, combined with the more common use of private consultation in obstetric difficulties, would have a marked effect on the mortality both of mother and child arising from childbirth. Examples are found in the case of accidental hæmorrhage, usually a toxic condition associated with albuminuria which causes a fœtal mortality of 60 to 70 per cent., and placenta prævia the cause of 253 maternal deaths in England and Wales in 1920 ; both these forms of antepartum hæmorrhage should be treated in hospital. Rupture of the uterus may follow a transverse lie or the untimely and unskilled performance of version or forceps extraction, and is a result obviously avoidable by the provision of skilled midwifery. It may follow on the presence of the higher degrees of pelvic contraction or the presence of a tumour or ovarian cyst in the pelvis, conditions which should have been detected by antenatal examination. Reference should be made to pre-existing organic disease ; patients with organic heart disease or tuberculosis especially, may with advantage receive antenatal care.

Antenatal Supervision.—The most important items of the work carried out at an antenatal clinic are the frequent and regular examination of the urine of pregnant women, a detailed examination of every primigravida in the early months of pregnancy and a detailed obstetric examination of every case in the last fortnight of pregnancy, primigravida and multigravida alike, especially for the detection and version of breech presentations. Other ailments such as varicose veins, malnutrition and defective teeth can be discovered and treated; mothers presenting signs of venereal disease will be recommended to attend the venereal diseases clinic; the condition of the mother's nipples will be ascertained and appropriate advice given and the importance of feeding the coming baby on the breast pointed out. Advice on the mode of life to be followed during pregnancy, the avoidance of lifting of heavy weights, etc., mentioned, also recommendations as to diet, action of the bowels, washing, dress, etc., made.

The Rules of the Central Midwives' Board require the midwife when engaged to attend a confinement, if illness or abnormality has occurred in the previous pregnancy or if it has ended in an abortion, premature labour or a stillbirth, to explain that the case is one in which skilled medical advice is required and to urge the patient to seek such advice; also if any abnormality occurs during pregnancy the midwife must explain that the case is one in which a doctor is required and must fill in the form of sending for medical help. These abnormalities or complications include deformity or stunted growth, loss of blood, abortion, or threatened abortion, excessive sickness, puffiness of hands or face, fits or convulsions, dangerous varicose veins, purulent discharge or sores of the genitals.

To ensure the doctor or midwife being engaged early the payment of maternity benefit should be made conditional on the woman engaging a certified midwife or a qualified medical practitioner at least 12 weeks before the date of the normal term of delivery. The voluntary notification of pregnancy is encouraged in several towns, notably Huddersfield.

Puerperal Sepsis—The Royal College of Physicians, on being appealed to by the London County Council, defined puerperal fever as including "septicæmia, pyæmia, septic peritonitis, septic metritis, and other septic inflammations in the pelvis occurring as the direct result of childbirth." But a definition is required which will assist practitioners in recognising the disease at its inception. In December, 1905, the late Sir W. J. Sinclair placed before the N.W. branch of the Society of M.O.H. the following: "For the purpose of the Notification of Diseases Act, 1889 and 1899, the term puerperal fever shall include all cases in which, within seven days after the birth of the child, alive or stillborn, the mother shall have a rise of temperature exceeding 100·4° F. with quick pulse, maintained for a period exceeding 24 hours, without any obvious cause, other than the puerperal state. 'It shall also include all cases in which in the same period there has been the occurrence of rigor, with attendant illness, without any obvious cause other than the puerperal state.' The term 'puerperal sepsis' is used by the Registrar-General in the short list of the causes of death; it may be remarked that 'puerperal sapræmia' is included under 'puerperal sepsis ' in the Manual of the International List of the Causes of Death which is used for classifying the causes of death in this country. The Registrar-General asks that the use of the indefinite term puerperal fever should be avoided by stating the form of puerperal infection, *e.g.*, puerperal pyæmia, puerperal septicæmia, puerperal septic intoxication," etc., etc.

The standard of puerperal morbidity arrived at by the British Medical Association in 1922 was that all cases should be included in which during the second to the eighth day a rise of temperature over 100° F. occurred twice in twenty-four hours. It has been thought that in an ordinary properly-run hospital a morbidity rate of about 8 per cent. might occur—6 per cent. would be a more or less satisfactory rate and 20 per cent. unsatisfactory, requiring investigation. The rate should be expressed in percentage of deliveries both including and excluding fatal cases.

The zone of skin with the anus as centre is held by some to be the breeding-ground of the organisms from which they are transferred by the fingers and instruments of the attendant to the uterus. General agreement, however, has not been reached as to the source of the infecting organisms which may well be from a source other than the patient. Puerperal fever has been described as a " dirt disease," like erysipelas and wound infection in general, the causal organisms being the same. The fact that cases of puerperal sepsis, both mild and severe, occur in patients who deliver themselves without any vaginal examination or operative interference, is proof that autogenous infection can occur ; in such cases it must be allowed that the organisms are at least present in the cervix from the beginning. On the other hand, it is pointed out that these cases are limited in number, and that most of them are of gonorrhœal origin. The commonest organism found is a streptococcus of the fæcalis type, occurring in short chains and found more often in the milder cases, while the Streptococcus pyogenes in long chains is more usual in the very serious types. Bacillus coli communis is a frequent accompaniment, but may be present alone. In sapræmia, due as a rule to the retention in the uterus of a small fragment of placenta, membranes or blood clot, the infecting organism is the fæcal streptococcus of low virulence, which in the presence of dead tissue is a facultative saprophyte and causes decomposition ; definite sepsis may develop in a case which began as a simple sapræmia. Vaginal discharge at the time of labour, dirty clothes and pads have been held responsible for some of the puerperal fever in the past. In a series of 250 cases, retained placenta was present in 37 per cent. ; gross laceration of the cervix following the application of forceps occurred in 14 per cent. The number of instances in which the sepsis is associated with abortion is remarkable.

Prevention of puerperal sepsis is bound up with aseptic and antiseptic midwifery ; the number of occasions on which the finger or an instrument is introduced into the parturient canal should be limited to the irreducible minimum ; normal labour should be conducted without vaginal examination until expulsive pains occur. Any finger[1] or instrument used must be surgically clean and the vulvo-vaginal canal as clean as possible, the vulva and the perineum being rendered surgically clean. An adequate supply of clean sheets and towels is required during delivery. Local Authorities should be empowered to furnish on loan a sterile outfit and equipment at a reasonable charge, to be remitted in necessitous cases. Only a nurse trained in asepsis and antisepsis should be allowed to assist a medical man at confinements. Medical help should be summoned for the repair of all tears of the perineum. Forceps should not be applied until there is sufficient dilation of the cervix ; in all possible cases their place should be taken by the administration of pituitrin. Cæsarean section should be undertaken in preference to craniotomy. Digital extraction of the placenta is only justifiable if the patient is losing an abnormally large amount of blood. Internal manipulation intended to deliver or to assist delivery of the child, plugging the vagina, the use of cervical dilators, etc., call for the strictest antiseptic technique.

When a single case of puerperal fever occurs in the practice of a midwife it is rarely necessary to suspend her for a longer period than that necessary for disinfection. Diagnosis is admittedly difficult in the early stages of the disease ; doubtful cases among poorer inhabitants should be sent as early as possible into hospital for the purpose of diagnosis and early treatment.

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[1] In practice, rubber gloves should be worn.

CHAPTER XIII

VENEREAL DISEASE

ALTHOUGH Osler's contention, that syphilis is the third on the list of killing diseases, is not accepted by all authorities, it is an undoubted fact that venereal disease is responsible for an enormous amount of damage to the community.

In the final report of the Royal Commission on Venereal Diseases, the conclusion is arrived at from study of certain selected groups of patients that " the number of persons who have been infected with syphilis, acquired or congenital, cannot fall below 10 per cent. of the whole population in a large city, and the percentage affected with gonorrhœa must greatly exceed this proportion." During 1922 the number of new cases attending the hospitals included in the London and Home Counties Scheme, dealing with a population of 9,716,684, was 23,811, of which 6,809 had syphilis, 10,632 gonorrhœa and 321 soft chancre.

In assessing the importance of syphilis as a death-dealing disease, the official returns of the Registrar-General are of little use. In the year 1919, 1,857 deaths were returned as being due to syphilis, a figure that is remarkably small considering the prevalence of the disease. If, however, it were possible to include all the deaths due to diseases resulting from syphilis, a much higher figure would be obtained. By adding to the 1,857 deaths due to general paralysis of the insane, locomotor ataxy, and aneurism, the figure 4,722 is reached. Even this represents but a fraction of the whole, for it is impossible to estimate the part played by syphilis in many fatalities, and in any case there is a tendency for practitioners to avoid using the word " syphilis " on a death certificate. But even apart from its importance on the mortality rate, venereal disease is responsible for an enormous amount of damage to health, loss of efficiency, invalidism and poverty. Bishop Harman stated before the Royal Commission that more than half the cases of blindness amongst children resulted from venereal disease in the parents, and it is known that 25 per cent. of congenital deafness is due to inherited syphilis.

Equally striking are the figures obtained from asylum records. General paralysis of the insane supplies the asylum with about 10 per cent. of its inmates, the average annual number of cases entering public institutions during the years 1909–13 being 1,604. To this figure must be added other diseases of the central nervous system due to syphilis, such as locomotor ataxia and various forms of sclerosis of the brain and spinal cord. According to E. R. T. Clarkson, "the total annual sum expended on the maintenance of V.D. patients in various asylums through England and Wales may approximately be recorded as costing some £300,000 per annum." But these calculations have been made from figures prior to the War, and are probably an under-estimation for the present state of affairs.

These facts are sufficient to show the importance of V.D. as a public health problem. Most of the figures given have referred to syphilis, but there are some who believe that although less dramatic in its course, gonorrhœa is in the long run responsible for more ill-health and distress (especially in women) than syphilis. Whilst syphilis is one of the commonest causes of miscarriage, gonorrhœa, either in the male or female, is responsible for a very large proportion of sterile marriages.

Method of Spread—By far the greatest number of cases of venereal disease are acquired by direct contact and in the great majority of instances by direct contact during the sexual act. This is partly accounted for by the fact that the skin and mucous membrane of the genitalia are very delicate and that slight abrasions are likely to occur as the result of coitus. Formerly it was generally accepted that for the Spirochæta pallida to gain entrance into the body a solution of continuity of the epithelium was necessary. Recent experiments have, however, shown that, given favourable conditions of warmth and moisture, the spirochæte has the power of penetrating the normal epidermis. However, though this may be the case, it is certain that the vast majority of syphilitic infections occur through an abrasion of the epithelium, be it ever so slight. Apart from transmission through the sexual act, syphilis is occasionally disseminated by kissing. Infection of medical men, midwives, and nurses through contact with syphilitic patients occasionally occurs, the most common situation for the chancre in such instances being the index finger of the right hand. Fortunately the infectivity of patients in the tertiary period is very low, otherwise infection following operations on such cases would be much less rare than is actually the case. Infection has occurred during post-mortem examinations.

Although cases of innocent infection by means of towels and drinking utensils are known, their number is sufficiently small to show that venereal disease is very seldom conveyed in such a manner. The comparative rarity of infection, apart from the sexual act, is probably associated with the rapidity with which the Spirochæta pallida and gonococcus die *in vitro*. The mere fact of the drying of a gonococcal discharge on a towel is sufficient to sterilise it. Were it not for this fraility of the organisms, cases of innocent gonorrhœa and extra-genital chancre would be extremely common.

From a practical point of view, the most important infecting article is the ordinary face towel; it has been shown that the organism of syphilis may live for at least 11½ hours under conditions that simulate those on a towel. In the case of gonorrhœa, infection may be spread by such an object until any discharge adherent to the towel has dried, when it may be regarded as sterile. In female children this method of spread through the use of infected towels is extremely common, and has been the source of troublesome epidemics in hospitals and orphanages. For this reason rigorous methods of prevention must be adopted should a case of infection occur in a child who is the inmate of a public institution. Drinking cups and glasses have also been the means of spreading syphilitic infection, but the spirochæte does not live on glass longer than an hour. The seats of public conveniences have been charged with frequently conveying syphilitic infection, but they are probably not of such great importance in this respect as they were once considered. It is not unlikely, however, that they are responsible for a certain number of cases of gonorrhœa. Tattooing and the practice of vaccination from arm to arm have both been the means of conveying syphilis; so also have gynæcological and dental instruments as well as razors.

THE PREVENTION OF VENEREAL DISEASE

Venereal disease, since the infective agents and their methods of spread are well known, is essentially a preventable disease. But the fact that venereal disease is spread through the sexual act, and is generally the result of promiscuous intercourse, renders difficult the adoption of means of prevention. Any scheme for the eradication of venereal disease is bound to come up against the primitive instinct of sex, and it is impossible to handle the problem in the same way as other infectious or contagious diseases. It is true that by certain members of the community, promiscuous intercourse is not considered a moral offence, but even such people attach a definite stigma to the contraction of venereal disease, and as a result concealment is encouraged. Measures for the prevention of venereal disease include (1) social measures and education; (2) prophylaxis or disinfection of individuals who have exposed themselves to the risk of infection; (3) the efficient treatment of those already infected.

Social Measures and Education—Amongst these are such measures as those directed to the reduction of alcoholism and to the improvement of public morals; education on the subject of sex and the dangers of venereal disease; the closing of questionable baths and resorts of ill repute; the increasing of housing facilities, and the provision of means for public recreation and games.

Although these measures have in the past been regarded as falling into the province of the social worker, their effect on the prevalence of venereal disease is so important that they cannot be disregarded by those responsible for the public health. For example, it has been found that there is a very direct relation between the attendance at the venereal clinics and the amount of propaganda and educational work carried out in the neighbourhood. For this reason a certain amount of public money has been allotted for publicity work throughout the country, this work generally being carried out by means of voluntary societies.[1] There is no doubt that many of the problems with which social workers are struggling are related to venereal disease, and that improvement in the general conditions under which a community lives is invariably followed by a fall in the venereal rate.

Prophylaxis—The principle measures advocated for preventing the development of venereal disease in a person who has exposed himself to infection are (1) immediate self-disinfection, (2) skilled disinfection at the hands of another individual, either a doctor or a trained attendant. The merits of these two different systems of disinfection have been the subject of much controversy, as indeed has been the whole question of prophylaxis. It is obvious that self-disinfection, provided it be efficient, has a much wider range of utility than disinfection by another individual, for the latter presupposes the existence of a clinic or of a private practitioner willing and able to perform such services. Self-disinfection is also less likely to entail delay, a factor which is of prime importance in determining success or failure. In favour of skilled disinfection has been urged the fact that a considerable number of individuals fail to carry out instructions properly, and as a result of this, disinfection is unsuccessful.

It is probable that both systems of disinfection have their sphere of utility. When skilled disinfection is available, either at a clinic, in an ablution room attached to a public convenience, or at the hands of a medical man, it is obvious that it is preferable to unskilled disinfection, provided that it can be carried out within an hour of exposure. When, however, skilled disinfection is unobtainable or only available after delay, self-disinfection must be employed. In order that it may succeed, it must be carried out in the most thorough manner possible, and with the least possible delay.

The prophylactic measures that have been recommended for the prevention of venereal disease in individuals who expose themselves to the risk of infection are: (1) The use of a rubber sheath or condom; (2) Micturition as soon after coitus as possible; (3) Washing the genitalia in soap and water and afterwards in some suitable disinfectant (a solution of potassium permanganate, 1 in 3,000, or hydrarg. perchlor., 1 in 5,000); (4) Unction of the genitalia and surrounding areas of skin with calomel ointment (33 per cent.). In order that disinfection may be efficient particular care must be taken that the prepuce is retracted and the coronal sulcus and lips of the meatus are thoroughly disinfected. A small amount of calomel cream should be worked into the urethra. If delay has occurred it may be advisable to wash out the urethra with a mild disinfectant. The use of calomel cream before as well as after exposure is to be recommended.

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[1] V.D. Circular 21 of the Ministry of Health allows propaganda work to be considered part of the scheme.

Obviously it is important that knowledge of these matters should be conveyed to those members of the public alone to whom such information will be of benefit and not a source of harm; discretion must be exercised to prevent propaganda on the subject falling into unsuitable hands. Unfortunately the use of prophylactic methods is practically restricted to the male. For anatomical reasons it is almost impossible for the female to disinfect herself successfully, although by the use of douches, pessaries, etc., she may reduce the likelihood of infection.

The Efficient Treatment of Those Already Infected—The efficient treatment of the already infected individual constitutes an important part of the preventive campaign, for it is the infected and incompletely cured individual that is responsible for spreading the disease. It was in order to cope with this difficulty and to provide facilities for the treatment of such infected individuals that the Public Health Venereal Diseases Regulations of 1916 were introduced. By agreement with the governing bodies of certain hospitals various facilities were provided, both for diagnosis and the treatment of V.D. Amongst these were:—(*a*) the obtaining of scientific reports on any material which a practitioner might submit from patients suspected to be suffering from V.D.; (*b*) the treatment at or in the hospital of persons of either sex suffering from V.D.; (*c*) the supply, free of cost, to medical practitioners practising in the county, of salvarsan or its substitutes for the treatment of patients residing in the county, and for the prevention of the spread of V.D.

Investigation of Pathological Material.

The provision of facilities for obtaining reports on pathological material is of the very greatest importance. It is only by such methods that a definite diagnosis can be established in the earliest stages of venereal disease and the whole success of the anti-venereal campaign depends on early diagnosis and prompt treatment.

The methods of laboratory investigation most commonly employed are:

The detection of Spirochæta pallida in exudations obtained from suspicious sores. The discovery of the Spirochæta pallida (Treponema pallidum) by Schaudinn in 1905 provided the means of early diagnosis of syphilis. By the examination of serum obtained from a suspicious sore, it is possible to establish a diagnosis before the clinical features characteristic of the hard chancre become obvious. Serum may be collected from a sore in a capillary tube, the ends of which are afterwards sealed by heating in a flame. It is, however, preferable where possible to send the patient himself to the laboratory. Spirochætes are easily found in a primary sore provided no disinfectants have been used; sometimes it will be necessary to repeat the examination on several different occasions in order to arrive at a positive diagnosis.

Spirochæta pallida, when seen under the dark ground illumination microscope, is distinguished from other spirochætes by the following characteristics. Their coils are very fine (7 coils to the diameter of a red blood corpuscle). They are of a bluish or metallic colour, are very active in their movements and have a length of anything from 5–25 μ. The detection of the Spirochæta pallida in a lesion is absolute proof of syphilis. It may readily be found in primary and secondary lesions, but although present cannot be detected clinically in the tertiary stage.

The Wassermann reaction—This can be carried out on either blood or cerebro-spinal fluid; the minimal amount required by the pathologist varies with his technique, but not less than 2 c.c. of serum or 20 c.c. of cerebro-spinal fluid should be sent. Suitable outfits for the taking of specimens are obtainable at V.D. clinics. It is important that the serum submitted should be as fresh as possible, and tubes used for the collection of blood should be scrupulously clean and dry. They should be free from the presence of such disinfectants as carbolic acid, since this may influence the result of the test. Cerebro-spinal fluid obtained by lumbar puncture should if possible be untinged with blood, as in addition to the Wassermann reaction help may be obtained by a cell count and an estimation of the globulin present. Although the Wassermann reaction is of the greatest help both in the diagnosis and the control of treatment, it should be recognised that too much dependence should not be placed on it, to the exclusion of other considerations. The exact mechanism of the reaction is unknown, but probably depends on the elaboration in the body of the patient of certain substances produced by the activity of the spirochæte. These substances are not present for at least three weeks after the appearance of the primary sore, so that the Wassermann reaction is useless as a means of diagnosis in the earliest stage of the disease. The obtaining of a positive result is an almost absolute proof of syphilis, provided the technique with which the reaction has been carried out is beyond reproach. Although certain tropical complaints may give a partial reaction, the only disease other than syphilis giving a complete positive is Yaws, and this is not likely to cause confusion except in tropical regions. A negative result, on the other hand, is no guarantee that the patient is non-syphilitic. Again, as a guide to treatment, complete reliance, to the exclusion of clinical data, must not be placed on the reaction. For instance, a negative result may be obtained after a course of arsenobenzol, but does not necessarily mean the patient is cured. More reliance may, however, be placed on a series of negative Wassermann tests obtained after the cessation of all active treatment. In any case the result of the blood examination must be used in conjunction with clinical data.

The desirability of standardising the pathological tests employed in the diagnosis of syphilis is obvious. Only when uniformity is introduced into the technique and method of reading the Wassermann test carried out in the numerous clinics throughout the country can any satisfactory comparison be drawn of the results of treatment afforded at these centres. Indeed it would be of the greatest convenience if some international agreement could be reached in the matter.[1] Dreyer's sigma test, a precipitation test carried out with serum, is gaining in popularity; it is not, however, yet in general use and is not officially recognised by the Ministry of Health.

Gonococcal fixation or complement deviation test—This reaction is dependent on the same principle as the Wassermann reaction. The technique is very similar. In the gonococcal fixation test, however, the "antigen" consists of an emulsion of gonococci. As in the case of the Wassermann reaction reliance can only be placed on positive results. As yet the application of the test is very limited, although with improvement in technique it should in the future prove of greater utility.

Detection of gonococci in specimens of pus—Two methods may be employed for this, the examination of films, and the making of cultures. In the case of the patient not attending a clinic the former method alone is usually employed. A small amount of pus from the urethra is spread over the surface of a microscope slide, allowed to dry in the air, and then sent to the pathologist for examination. The gonococcus is a Gram negative capsulated diplococcus, reniform or biscuit-shaped, and found within the body of the leucocyte. It is grown only with difficulty and special culture media (legumen agar, serum agar, etc.) must be employed.

In the male the gonococcus is usually found without difficulty during the acute stage, but later becomes less plentiful in the pus. In the female its detection is a matter of considerable difficulty, and in order to assist the pathologist great care must be exercised in the taking of specimens. The situations in which it is likely to be found are in the cervical canal, the urethra and the openings of Bartholin's glands. A single negative report is not sufficient to justify an assumption that the patient is free from the disease. Owing to the special difficulties attending the obtaining of specimens in the female, it is better, if possible, to make arrangements for the patient to attend a clinic.

Soft Sore or Chancroid— This condition is gradually becoming more and more rare in the United Kingdom, and cases are very seldom seen at a venereal clinic. It is generally believed to be due to infection with Ducrey's bacillus, a Gram positive strepto-bacillus which grows in chains of varying length. As, however, these organisms can only be detected with the very greatest difficulty, an examination for their presence in a sore is not of any practical utility in establishing a diagnosis. For this purpose a search for Spirochæta pallida in order to exclude the possibility of syphilis should be made, and until that possibility is definitely excluded no disinfectants should be applied to the sore.

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[1] See "The standardisation of pathological methods" (Special Report Series, No. 14, Medical Research Council).

TREATMENT

To ensure that infected individuals could obtain efficient treatment, arrangements were made in 1916 by the Local Government Board for the establishment of clinics throughout the country. The chief aim of these clinics is to render patients suffering from V.D. non-infectious. The mere alleviation of symptoms, while leaving the patient a carrier of infection, would be worse than useless, for it would enable such individuals to return sooner to their old mode of life and thus encourage the conveyance of infection to others. The extent to which the clinic achieves its object of rendering patients non-infectious is the measure of its success.

THE ORGANISATION AND EQUIPMENT OF V.D. CLINICS.

The *premises* used for the treatment of V.D. should always form part of a general hospital or some other institution concerned with the treatment of diseases other than venereal; *ad hoc* clinics are strongly to be condemned as their character soon becomes known to the public and patients are afraid to be seen visiting them. As a rule premises must be used which, not having been built for the purpose, are not, strictly speaking, suitable. If the clinic is held in the general out-patient department of a hospital, there is the additional disadvantage that the premises are only available for the treatment of V.D. at certain hours and on certain days when they are not being used for other purposes. When utilising such improvised premises, every effort must be made to ensure privacy both in the waiting-rooms and during treatment, as otherwise the more sensitive patients will soon cease to attend. If possible the clinic for female patients should be entirely apart from the male, so that it may not be necessary to treat males only on one day and females on another.

Hours of Attendance—In order to encourage regular attendance every consideration should be shown to the patients with regard to the hours during which the clinic is open. The majority of those who attend the clinics are workers and for this reason sessions during the evenings and on Saturday afternoons are the most popular. If the clinic cannot be open every day arrangements must certainly be made for the carrying out of intermediate treatment (irrigation, etc.) during the intervals. The irrigation rooms must not, therefore, be utilised for any other purpose.[1] The existence of a few beds for in-patient treatment is of great utility, but owing to the fact that with the Salvarsan substitutes in general use, severe reactions are rare, the provision for retaining patients in hospital need not be at all extensive.

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[1] See V.D. Circular 19 of Ministry of Health urging extension of facilities for treatment and giving examples of treatment at auxiliary centres (intermediate treatment).

Certificates of Freedom from Disease before Marriage

As the result of propaganda the public is slowly realising that an individual who has suffered from venereal disease in the past is under a moral obligation to take every step to ascertain whether he is cured before marrying and subjecting another person to the risk of infection. In some clinics a special marriage test is carried out.

ENFORCEMENT OF THE CONTINUOUS TREATMENT OF VENEREAL DISEASE

Compulsory notification and comprehensive legislative measures have already been introduced into various parts of the British Empire, as well as into some of the Federal States of U.S.A. and Continental countries. The main objects aimed at by these legislative measures are to discover infected members of the community, and to ensure that such persons receive adequate treatment and remain under treatment until cured, or at any rate, until non-infectious.

The methods that have been adopted to achieve the first of these objects are: making it compulsory for sufferers to consult a practitioner on discovering that he or she is suffering from V.D.; compulsory notification of such infected individuals by the practitioner to the local health authorities; compulsory examination of persons in prisons and public institutions or of any individual whom there is reason to believe is suffering from V.D.

The exact form which these legislative measures have taken varies in different countries, and a detailed consideration of them is beyond the province of this work. The second object, namely, that of ensuring that infected persons continue under treatment until cured, or at any rate until they are no longer infectious, is attained by a system of notification. In some countries notification of all patients applying for treatment is carried out (*e.g.*, Western Australia), and in others, notification only of those who fail to comply with the regulations and absent themselves while still potentially infectious (*e.g.*, certain provinces of Canada). These measures have not been sufficiently long in existence to allow of any final estimate being made of their value. It is obvious that various objections may be brought against a system of notification, since the moral stigma attached to venereal disease does not allow of it being considered as a true parallel to other notifiable diseases. It is felt by many that notification would result in concealment and would bring about a drop in the number of those attending the clinics. In the minds of others the chief objection lies in the fact that a system of notification would be difficult to put into action, and would necessitate the existence of a large number of officials occupied in the task of tracing defaulters.

Whatever the final step may be, in the opinion of the majority the time has not yet come for the establishment of any system of notification in the United Kingdom. It is generally felt that no such vital step should be taken until further experience is gained of the working of legislative measures in other parts of the world, and the provision for treatment is in all respects adequate.

SUPPLY OF FREE SALVARSAN SUBSTITUTES

Under the L.G.B. regulations of 1916, medical practitioners may be supplied with salvarsan preparations on showing a certificate that they have attended a course of instruction at a venereal clinic. V.D. Circular $\frac{219}{7}$, August 29th, 1916, defines the practitioners to whom salvarsan may be issued. The granting of certificates of qualification to undertake salvarsan treatment is in the hands of the medical officer in charge of the clinic, and the number of attendances required before such a certificate is given is entirely at the discretion of this officer.

Kharsivan, arsenobillon, novarsenobillon and sulfarsan are the salvarsan substitutes that have at present received the approval of the Ministry of Health.[1]

The Ministry of Health Circular 23, March 4th, 1918, accompanied by a memorandum by the Salvarsan Committee, prescribes that the patient is to be warned that he must be prepared to continue a full course of treatment, and must not regard amelioration of his symptoms as a cure. It gives the conditions requiring care and watchfulness in the administration of salvarsan, and mentions that the patient is to be watched in the course of treatment for certain untoward symptoms. The points requiring attention in preparing arsenical remedies for injection are included.

ANNUAL RETURNS FURNISHED BY VENEREAL CLINICS

For the purpose of statistics and for the information of public health authorities, medical officers in charge of clinics are required to furnish an annual report.[2] This annual return consists of two parts, the first dealing with the number of patients, new or otherwise, attending the clinics, the disease from which they suffered, the total number of attendances made, the percentage who completed their treatment and the percentage of those who left before the establishment of a cure. It also contains a column for pathological examinations, giving the number of Wassermann reactions, examinations for spirochætes and gonococci, and any further laboratory investigations that have been carried out. The second part of the return is geographical, and gives information as to the administrative areas from which patients were drawn. Figures obtained from this part of the report are forwarded to the several Medical Officers of Health concerned, in order that they may be able to estimate the incidence of V.D. in the area under their administration.

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[1] Circular 166, 20th Jan., 1921, gives a list up to date of approved substitutes for salvarsan. V.D. Circular $\frac{219}{3}$ deals with the leaflets to be used, approved substitutes for salvarsan, payment of councils for patients treated at hospitals not in their scheme.

[2] See Memorandum $\frac{219}{3}$ of the Ministry of Health as to the records to be kept and the returns to be made by institutions approved by the Local Government Board, for the diagnosis or treatment of venereal disease.

The two most striking facts that may be deduced from the consideration of the reports are firstly, that since 1920 a definite diminution has occurred in the total number of cases attending clinics, and secondly that a very large proportion of patients break off treatment before they have completed their cure. This second fact is of very grave import, as a certain percentage of the patients who cease to attend are undoubtedly capable of infecting the community. (In numerous clinics as many as 50 per cent. cease to attend before being certified as cured.) Various measures have been advocated for remedying this serious state of affairs. While it is felt by some that the solution lies in legislation and in the introduction of some form of notification and compulsory treatment, others consider that these measures would merely result in concealment of the disease and avoidance of the clinics. They hold that the tendency to leave off treatment before cure should be combated by means of increased propaganda and education, and the institution of some form of " follow up " system. In case of default, pressure is to be brought on the absentee by means of carefully worded letters and if necessary by a visit of the social worker attached to the clinic. A patent objection to this course is the danger of letters falling into the wrong hands.

The last column in the annual return deals with the forms of salvarsan substitutes used in the clinic, the dosage, the number of injections given and the tests applied before discharging as cured. In the majority of clinics throughout the country, the common practice is to begin with an initial dose of ·45 gram of salvarsan substitutes and work up to ·75 gram, or in some instances ·9 gram. The number of doses given to any particular patient will depend greatly on the personal opinion of the medical officer in charge, and it is impossible to lay down any dictum on the matter. Much difference of opinion still exists as to the amount of arsenobenzol treatment that a given case of syphilis will require, and no general agreement on this subject has yet been reached.

STANDARD OF CURE

Since it is the function of venereal clinics to retain their patients under treatment until non-infectious, and if possible cured, it is of primary importance that a definite standard should be established to which patients must attain before being discharged. In order that some uniformity might exist in clinics throughout the country, suggestions for a standard of cure were sent out by the Ministry of Health in 1919.

The tests carried out in all well-organised clinics are :—

For gonorrhœa in the male, the patient should be tested on three successive occasions, at weekly intervals, after the cessation of all curative treatment. He should have resumed his usual habits as regards alcohol, diet and exercise, and as a "provocative" one or more of the following should be employed :—

The passage of a full-sized metal bougie; the instillation of silver nitrate in the posterior urethra, or the injection of a large dose of gonococcal vaccine.

Careful search for pus cells and for organisms are made in fluid obtainable from the urethra, threads from the urine and prostatic and vesicular fluid obtained as the result of massage.

Should the bacteriological findings be negative on all three occasions in a patient clinically sound, he may be considered cured.

For gonorrhœa in the female similar tests should be carried out on three occasions immediately before and after the menstrual period. Specimens for examination are obtained from the urethra by digital pressure, from the urine, the cervical canal and the ducts of the glands of Bartholin. If possible both films and cultural methods should be employed.

In the case of syphilis, at the cessation of all curative treatment a Wassermann test should be made at intervals of three months, and a provocative injection of salvarsan given previous to the 5th and 9th of these serum tests. In the event of any of the above tests revealing signs of relapse, treatment should be resumed. After a greater period than four years has elapsed since the date of infection, the patient may for all practical purposes be regarded as non-infectious. He should, however, be advised in his own interest to continue treatment and to submit to subsequent observations and tests until it is reasonably probable that the disease has been eradicated.

STILLBIRTHS AND PRE-NATAL CLINICS

It is well known that a considerable percentage of stillbirths are due to syphilis. The lowest figure at which this can be put is 25 per cent., but in the case of illegitimate births it will probably be about double that figure. According to Amand Routh some 20,000 potential citizens are lost annually to England and Wales as the result of stillbirths due to this disease, quite apart from children dying of syphilis. In order to deal with this important problem, and also with that of congenital syphilis, centres have been established at which pregnant women suffering from syphilis may receive suitable treatment. The result of such treatment is eminently satisfactory as salvarsan is well supported by pregnant women. Even when treatment is only taken up at a comparatively late period (*e.g.*, the sixth month), the probability is that the child will be born free from obvious signs of disease. It is, however, too early to state dogmatically whether children born in such circumstances will remain free from the disease during their whole lives.

VENEREAL DISEASE AND THE MERCANTILE MARINE

The treatment of V.D. in a migratory population like the Mercantile Marine is attended with special difficulties. Although in-patient facilities are available at many of the ports, both British and Foreign, at which shipping stops,[1] out-patient treatment is seldom obtainable. As admission into hospital means that a seaman loses his ship, is left in a foreign country, and is made responsible for his own passage home, venereal disease, unless it causes total incapacity, is generally concealed. The need for providing better treatment facilities at seaports has been engaging the attention of the Health Section of the League of Nations, and of various Governments. The ideal is that an infected seaman should find facilities for treatment at every port at which he calls, so that by means of a card stating what treatment he has already received, he should be able to continue without interruption. In the case of ships carrying medical officers it is important that better provision be made for the treatment of V.D. along modern lines. Ships' surgeons should be required to have undergone a course of instruction in the diagnosis and treatment of venereal disease, and means of disinfection should be provided to men on shore-leave at ports of call. Port authorities should also take steps to prevent prostitutes from coming on board ships in port.

VENEREAL DISEASE IN THE ARMED FORCES

The loss of efficiency for which venereal disease is responsible in an Army is very great. It has been calculated by Colonel E. T. Burke, D.S.O., that even as early as the year 1912 the presence of venereal disease in the Services cost the country the sum of £275,000 per annum. Figures obtained from the late War bear still more striking testimony to the loss of man-power for which V.D. is responsible.

Owing to the existence of discipline, methods can here be adopted which are not applicable to the civil community. Amongst the measures which were found of value in the late War were the removal of prostitutes from camp areas; the limitation of hours of leave and especially of night leave; the putting out of bounds of places of ill repute; the encouragement of outdoor sports and recreations; the use of propaganda concerning the dangers of venereal disease, and the provision of facilities for the disinfection of those who in spite of propaganda expose themselves to the risk of infection. Concerning the value of prophylaxis in the Navy and Army, considerable difference of opinion still exists. The variable results obtained may to some extent be put down to the different amount of energy and enthusiasm displayed by Medical Officers in carrying out their work. But not only do opinions differ as to the precise value of prophylaxis but also as to the comparative merits of skilled and of self-disinfection. Broadly speaking, it may be stated that whereas the experience of the American forces was such as to endorse the value of skilled disinfection, amongst the British forces self-disinfection was on the whole regarded with greater favour. In the Navy, however, the value of the ablution chamber has been definitely approved. In certain ships all men returning from shore-leave are required to report themselves and to undergo disinfection at the hands of the sick-bay attendant.

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[1] See V.D. Circular 15 (28 Nov., 1918), prescribing course of procedure and case card for seamen suffering from venereal disease.

STATUTES RELATING TO VENEREAL DISEASE

There is little legislation actually in the Statute Book relating to venereal disease. By Sec. 5 of the Indecent Advertisement Act, 1889, 52–53 Vict. c. 18, the display of advertisements relating to V.D. is included among indecent advertisements punishable by a fine of 40*s*. By the V.D. Act of 1917, it was made illegal for anyone other than a duly qualified medical practitioner to treat or offer to treat for reward persons suffering from venereal disease.

KENNETH M. WALKER.

CHAPTER XIV

SCHOOL HYGIENE

School Medical Inspection—In August, 1907, the passing of the Education [1] (Administrative Provisions) Act made it an obligation on every local education authority to provide for the medical inspection of children attending the elementary public schools in the area of the authority. Previous to the passing of this Act a proportion (about 1 in 4) of the local education authorities in England and Wales had instituted schemes of medical inspection. The reports of Inter-departmental Committees—on Physical Deterioration (1904), on Medical Inspection and Feeding of Children in Public Elementary Schools (1905), had gradually aroused in the public mind a feeling that a national inquiry into the physical condition of the children in the elementary schools was urgently called for, and contributed largely to the passing of the Act.

The Act in addition gave *power* to local education authorities to provide, subject to the sanction of the Board of Education, treatment for the elementary school children of the area. During the years which followed an increasing number of local education authorities instituted and developed treatment schemes, and, by the passing of the Education Act, 1918, it became an obligation on all local education authorities to provide treatment for their elementary school children.

The relationship of the newly-created school medical service to the existing public health service required definition. Accordingly in 1907, the Board in Circular 576 defined the position and advised that as a general rule the medical officer of health of the county, county borough, or borough, should also be appointed school medical officer, thus ensuring complete co-operation between the two services. The Ministry of Health Act, 1919, and Circular 1131 (Ministry of Health), 1919, further emphasized the need for co-operation under the new conditions arising out of the Act of 1919. Other early Circulars of the Board relative to medical inspection were Circulars 582 and 596—the latter dealing, *inter alia*, with the duties of the school medical officer.

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[1] The majority of the Acts to which reference will be made have been consolidated in the Education Act, 1921.

In 1908, a model scheme of inspection with schedules was issued by the Board. The age-groups to be examined were defined in 1925 as follows :—

(1) All children as soon as possible after their first admission to public elementary schools, and in any event, not later than twelve months after that admission.
(2) All children who were between the ages of seven and eight on the first day of the calendar year.
(3) All children who had attained the age of twelve on the first day of the calendar year, and have not been previously medically inspected after attaining the age of twelve.

Children so examined are called " Routines," and the groups are respectively " Entrants," " Intermediates " and " Leavers."

Two other groups of children are examined other than " Routines," as above defined, *viz.*, " Specials," and " Re-examinations." " Specials " are children not falling under a code age-group whom it is nevertheless considered desirable to examine. Such children include those with uncorrected defects from previous years, children who are suspected of, or are known to suffer from, defects which have arisen since the last medical inspection of the child, *e.g.*, otorrhœa, children who are bad attenders and so on. " Re-examinations " are children examined for the second time in the same calendar year.

Liability to Submit to Medical Inspection—The question of the liability of parents to submit their children to medical inspection is an important one. The local education authority under Section 122 of the Children Act, 1908, may direct their medical officer, or any person provided with his authority in writing (in the case of girls, such authority can only be delegated to medical practitioners or women) to examine " in any public elementary school provided or maintained by the authority, the person and clothing of any child attending the school," and if the child is found to be " infected with vermin, or is in a foul or filthy condition " may direct the parent or guardian to undertake the necessary cleansing within 24 hours, etc.

In the case of Fox v. Burgess (King's Bench Division, 25/1/22), an appeal against the conviction of a parent under this Act for withholding a child from medical inspection under the Act was dismissed with costs.

It is an obligation on the parents of certain other groups of children to submit their children to medical examination, *e.g.*, mentally defective and epileptic children. (Elementary Education (Defective and Epileptic Children) Act, 1899, Section 1 (4)).

There is, however, no obligation on a parent to submit his child to *routine* medical inspection. (Local Education Authorities (Medical Treatment) Act, 1909, Section 3).

Following-up—The defect having been noted at the medical examination it remains to take steps to ensure that necessary treatment is obtained. These steps have now come to be classified under the title of "Following-up."

Following-up in the main falls under three heads:—

(*a*) Correspondence,
(*b*) The work of the school nurse,
(*c*) The work of care committees.

Correspondence, in the shape of letters, forms, etc., from the school medical officer's office, is only of limited application—it lacks the personal touch. It is, however, of value in the preliminary notification of defects, schemes of treatment, etc. It has the advantage of giving parents reasonable time to consider the questions arising.

The work of the school nurse has proved beyond calculation valuable. The nurse lives in her area, gets to know the people of the area, and, armed with a complete knowledge of the dangers of neglected defects, of methods of treatment of minor ailments—uncleanliness, skin diseases, discharging ears, external eye defects and the like, and of the working of the education authority's schemes of treatment for major ailments, of the home circumstances and other relevant matters, her contribution to the successful working of a school medical department is of inestimable value.

Care committees have been formed in many areas, notably large urban areas and cities. These consist of voluntary workers, interested in the welfare of the children, who by their arduous labours supplement the work of the school medical service in a remarkable way. They attend medical inspections and visit the homes of children requiring treatment, explain matters to the parents, and arrange for, or assist with, the arrangements for the treatment of defects. They have other activities, referred to elsewhere, such as assisting with the employment of children leaving school, providing clothing, medicines and surgical appliances for the very poor, assisting with the feeding of school children, holidays for the ailing, thrift clubs, prevention of cruelty, organisation of meetings for parents to discuss school hygiene, juvenile employment, etc. The work of these devoted workers has earned high praise from the Chief Medical Officer of the Board.

In London the care committees usually consist of a chairman, secretary, representatives of school managers, and several other members for an average school, with the head teachers as co-opted members. The chairman and working members are expected to devote at least two days of five (school) hours weekly to the work.

Other agencies assisting in following-up are school attendance departments, and, among voluntary agencies, the National Society for the Prevention of Cruelty to Children, the Invalid Children's Aid Association, the Central Committee for the Care of Cripples, the Fresh Air Fund, etc.

Treatment—The treatment of defects found at the medical examinations at the schools falls under four main heads :—

(*a*) By general practitioners.
(*b*) At school clinics.
(*c*) At hospitals.
(*d*) At special schools.

(*a*) *General Practitioner Treatment*—It is only necessary to say with regard to this that it is the wish of the Board of Education that as far as possible all cases should be referred to the family doctor in the first instance. After that, necessitous cases, cases calling for special treatment, and cases of a trivial nature, *e.g.*, impetigo, should be dealt with otherwise.

(*b*) *School Clinics*—The Chief Medical Officer of the Board in his report for 1923 gives the number of school clinics in operation as 1,029. The attendances at these is very large indeed, amounting to some millions annually. The school clinic in practice operates as a treatment centre for minor ailments, dental, eye, and other defects, and as a consultation centre or " clearing house " from which ailing children can be referred to other branches of the school medical service or of the public health service, *e.g.*, the open-air school or the tuberculosis dispensary. It is a convenient meeting-place for discussion between the school medical and attendance departments. It is an obvious advantage to the co-ordination of the public health services in any area if the school clinic, tuberculosis dispensary, maternity and child welfare centre, etc., can all be accommodated in one building. In large areas this is not so easy to arrange, but in smaller areas, where in fact the same medical officer may undertake the work of the various departments, it is an efficient and economical plan.

The buildings of a school clinic should be centrally placed for the area supplied, easily accessible by train, bus, or tram, and should be bright and cheerful, with very good lighting. The accommodation required depends upon the work to be undertaken, but the minimum is a waiting-room, a consulting-room and a treatment-room. Additional services, *e.g.*, dental, ophthalmic, etc., call for special accommodation. Cleansing of verminous children implies bathing provision, and lavatory accommodation is always essential.

The following table shows the large amount of treatment provided in school clinics for the year ended 31st March, 1923 :—

Total number of school clinics.	Providing treatment for minor ailments.	Providing dental treatment.	Providing operative treatment for tonsils and adenoids.	Providing X-ray treatment for ringworm.
1,029	782	616	111	49

By *Minor Ailments* are implied such conditions as impetigo, scabies, and other skin diseases, septic sores, burns, etc., otorrhœa and conjunctivitis, blepharitis and other minor eye conditions. For the treatment of such the clinic should be open daily, but in rural areas this may not be possible. In such areas the medical officer may attend once a week, the school nurse attending on such of the intermediate days as can be arranged. The establishment of clinics for the treatment of minor ailments has done more than any other measure to reduce the loss of school attendances on medical grounds. Other forms of treatment provided at school clinics are ophthalmic, dental, operative treatment of tonsils and adenoids, X-ray treatment of ringworm, orthopædic, etc.

[Sir George Newman instances the Highgate New Town Clinic, London, as the one most elaborately equipped for the provision of different forms of treatment in this country.]

(*c*) *Treatment at Hospitals*—Most authorities supplement their school clinic treatment by subsidising hospitals in the area to undertake one or more branches of treatment. Some 186 Authorities adopt this plan, 381 hospitals being so subsidised in 1922. It may not, for example, be practicable to undertake the operative treatment of tonsils and adenoids at a school clinic and it is usually easy for a hospital to make the necessary provision. Many school children, of course, are treated at hospitals on direct application.

(*d*) *Treatment at Special Schools*—Certain groups of abnormal children require special provision for their education and treatment and to meet the need "special" schools have sprung into existence. These may be day or residential. Such schools provide mainly for the treatment and simultaneous education of blind, deaf, mentally defective, epileptic, crippled, tubercular and debilitated children. The following Acts require local education authorities to make the necessary provision for the respective groups of children dealt with in the Acts, and sanction the payment of grants in respect thereof :—

The Elementary Education (Blind and Deaf Children) Act, 1893,
The Elementary Education (Defective and Epileptic Children) Act, 1899,
The Mental Deficiency Act, 1913,
The Elementary Education (Defective and Epileptic Children) Act, 1914,
The Education Act, 1918.

The number of such special schools in England and Wales at 31st March, 1923, was 508, with a total accommodation of nearly 40,000 beds. Board of Education List 42 gives a complete list of all special schools. Parents are liable to contribute to the maintenance of abnormal children at special schools and are under an obligation to cause them to be specially educated.

The Act of 1893 defines a blind child as "one who is too blind to read ordinary school books," and a deaf child as "one who is too deaf to be taught in a class of hearing children."

Education becomes compulsory[1] in the case of blind children at the age of 5 and in the case of deaf children at the age of 7; education must continue until the age of 16. Vocational training may be prolonged after that age at approved institutions.

Similar provision must be made for mentally defective and epileptic children from the age of 7 until the age of 16, but in these cases parents have the rights of withholding consent to the removal of a child from the elementary school and of withdrawing a child from a special school if they can show proof of making "suitable provision" in some other way.

Poor Law authorities are, for the most part, the responsible authorities for children under their care in respect of these Acts.

The expiration of the compulsory period of special school treatment and training does not, of course, mean that the problem of the care of these children automatically ceases. In the case of blind and deaf children supervision by after-care committees or otherwise is a prime necessity—to continue training, to find employment, to dispose of the products of home work by these children in handicrafts learned whilst under training and generally to help them to be wage-earners in spite of their handicap.

Epileptic children may be handed over by the education authority at the age of 16 to the care of the Guardians who may, if considered necessary, continue to maintain them in institutions.

With regard to mentally defective children it is the duty of the education authority to notify to the mental deficiency committee of the area the names and addresses of all children about to be discharged from a special school or class whom it is desirable to send to an institution or to place under guardianship.

The curriculum of the special schools for these various types of defective children includes a high proportion of manual work, basket making, chair carving, weaving, machine knitting, typewriting, woodwork, gardening, or the like, the handicrafts taught having special reference to the possibility of the defective children concerned becoming wage-earners therein. It is estimated that 50 per cent. of the blind, 80 per cent. of the deaf, and 40 per cent. of the mentally defective, can be trained to earn their own living.

In the case of crippled children the special schools where vocational training is undertaken fall into a somewhat different category. Recent developments in orthopædic treatment have brought into prominence the hospital school, where treatment is the prime consideration; the stay of the crippled child in hospital may often be prolonged, but with the development of after-care schemes the average stay is now much reduced, and education consists chiefly in the continuation of ordinary elementary education during the hospital stay. Vocational training is not so essential in this class of case, but the need for after-care committees to assist in the provision of suitable employment on leaving school is very great.

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[1] The Special Services Regulations, 1925, state that ' No child may be admitted to a Special School under 2 years of age, and no child may be retained after the end of the term in which he completes 16 years of age."

Open-air schools, day and residential, are a beneficent development of the school medical service. There are 37 open-air day schools and 25 residential open-air schools now approved by the Board. These provide accommodation for some 4,500 children. This totally inadequate provision is supplemented by open-air class-rooms, summer-camps (approved by the Education Act, 1918), school journeys (being holiday excursions lasting from a day to several weeks) and principally by the holding of ordinary school classes in the open-air in school playgrounds, parks, etc.

The children who benefit by these provisions vary from the normal child to the debilitated, malnourished, and pretuberculous. The definitely tuberculous are dealt with under schemes sanctioned by the Ministry of Health.

The open-air school idea had its origin in Germany and such schools had been in existence in that country for some years before the London County Council established the Bostall Wood Open-air School in 1907—the first in England. The average stay in the residential open-air school is six months. The open-air idea is bound to progress rapidly when economic conditions permit (as equally is the development of other types of special school) and, with anything like adequate provision being attained, cases will be sent at an earlier stage and the necessary duration of stay will be much reduced.

Payments by Parents—By the Local Education Authorities (Medical Treatment) Act, 1909, a parent is liable to pay for treatment provided by the authority, such charge, not exceeding the cost of treatment, as the authority may determine, and it is the duty of the authority to recover the cost (except in necessitous cases) if necessary through the county court under the Summary Jurisdiction Act, 1879.

Exclusions on Medical Grounds—In accordance with Article 53 of Elementary Education Provisional Code, 1922, the school medical officer may exclude children from school on the ground that—

(1) their exclusion is desirable to prevent the spread of disease,

(2) their uncleanly or verminous condition is detrimental to the other scholars,

(3) owing to their state of health, or their physical or mental defects, they are incapable of receiving proper benefit from the instruction in the school.

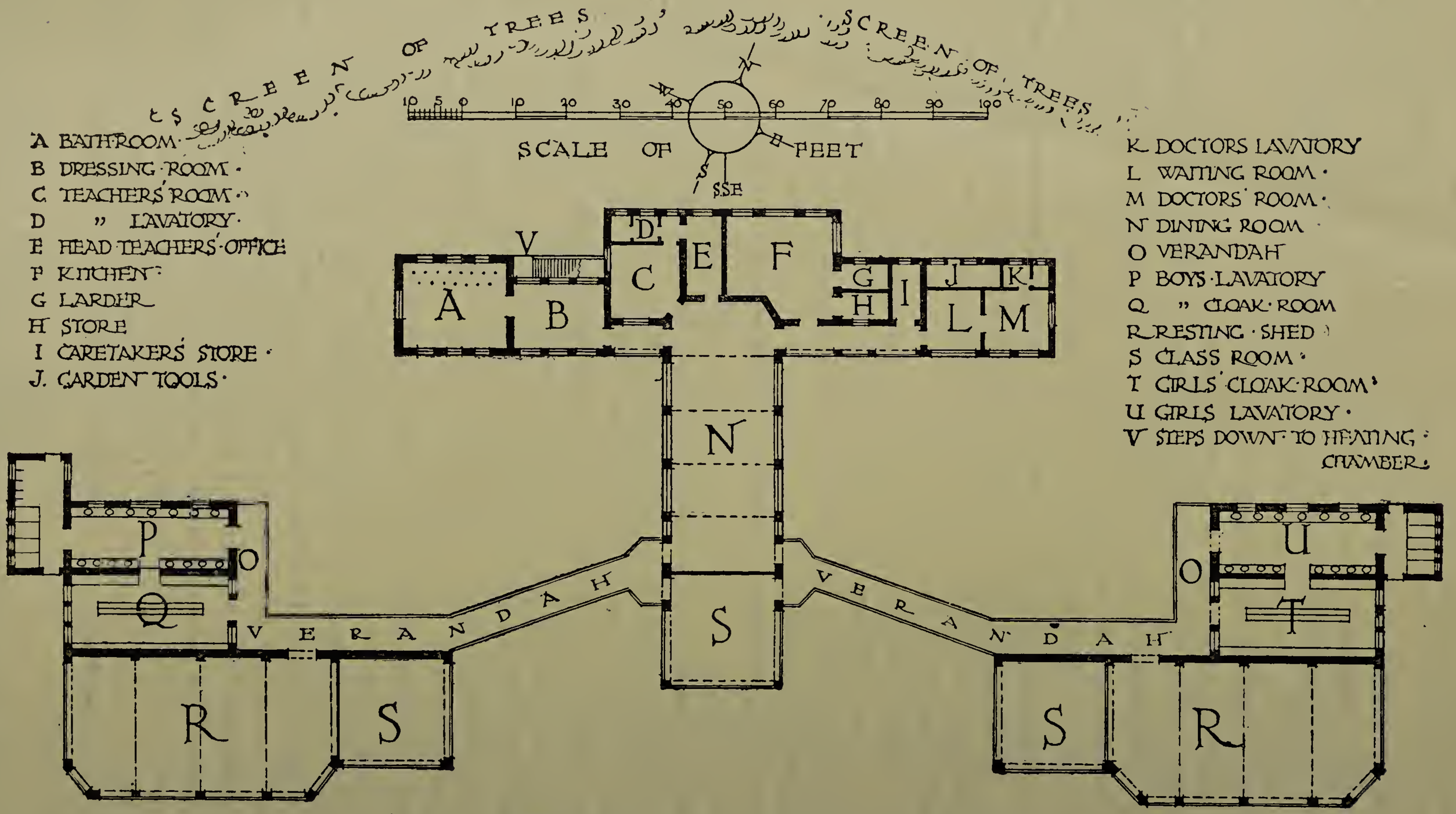

FIG. 91.—Suggested plan for Day Open-Air School for 150 children.

For the purposes of this provision the local education authority may direct that no children who have been excluded under the authority of the school medical officer or under Article 57 or who have been absent from school owing to sickness shall be re-admitted to school if the school medical officer is not satisfied that they can attend school without risk to themselves or others.

Uncleanliness—In no department have the benefits of the school medical service been more clearly demonstrated than in the promotion of a higher standard of cleanliness among school children. Prior to, and at the start of school medical inspection, girls' schools with 50 per cent. or even more of verminous heads were not uncommon. The percentage of body vermin in both sexes was also high. It is probable that if a simultaneous inspection could be undertaken of all the elementary school children in England and Wales at the present time not 10 per cent. would be found to be verminous. The measures which have effected this change have been the routine school medical inspections, instruction in personal hygiene, the growth of public opinion, the establishment of cleansing stations, prosecutions by education authorities and others, and *surprise visiting* by school nurses. Of these the last two have probably been the most effective. Verminous conditions, besides being intolerable in themselves, directly promote ill-health through the media of septic sores, impetigo, eczematous conditions, glandular enlargement and loss of sleep.

Since the passing of the Cleansing of Persons Act, 1897, local authorities (including boards of guardians) have had the power to establish cleansing stations for verminous conditions. Education authorities now have similar powers. Pressure may be put on the parents of habitually verminous children by education authorities providing cleansing stations under the Children Act, 1908, Section 122, which provides, that, after due notice to cleanse having been given and not complied with, the authority may remove the verminous child to the cleansing station, and there cleanse the person of the child and disinfect the clothing. If the child thereafter becomes verminous again the parent is liable on conviction to a fine of ten shillings. Education authorities not providing cleansing stations may prosecute under Section 12 of the same Act.

Cleansing stations should be provided *inter alia* with bathing facilities and means for disinfecting the clothing. Prosecutions are also sometimes undertaken by school attendance officers and by the National Society for the Prevention of Cruelty to Children.

The mere cleansing of the verminous child is in itself only a partial measure, and it is the duty of the education authority to bring to the notice of the sanitary authority the homes from which children are found habitually verminous, so that necessary action may be taken to disinfect the house and its contents. However, the adults and children below school age, whose persons are probably also infected, cannot be compulsorily cleansed. The term "vermin" is defined by the London

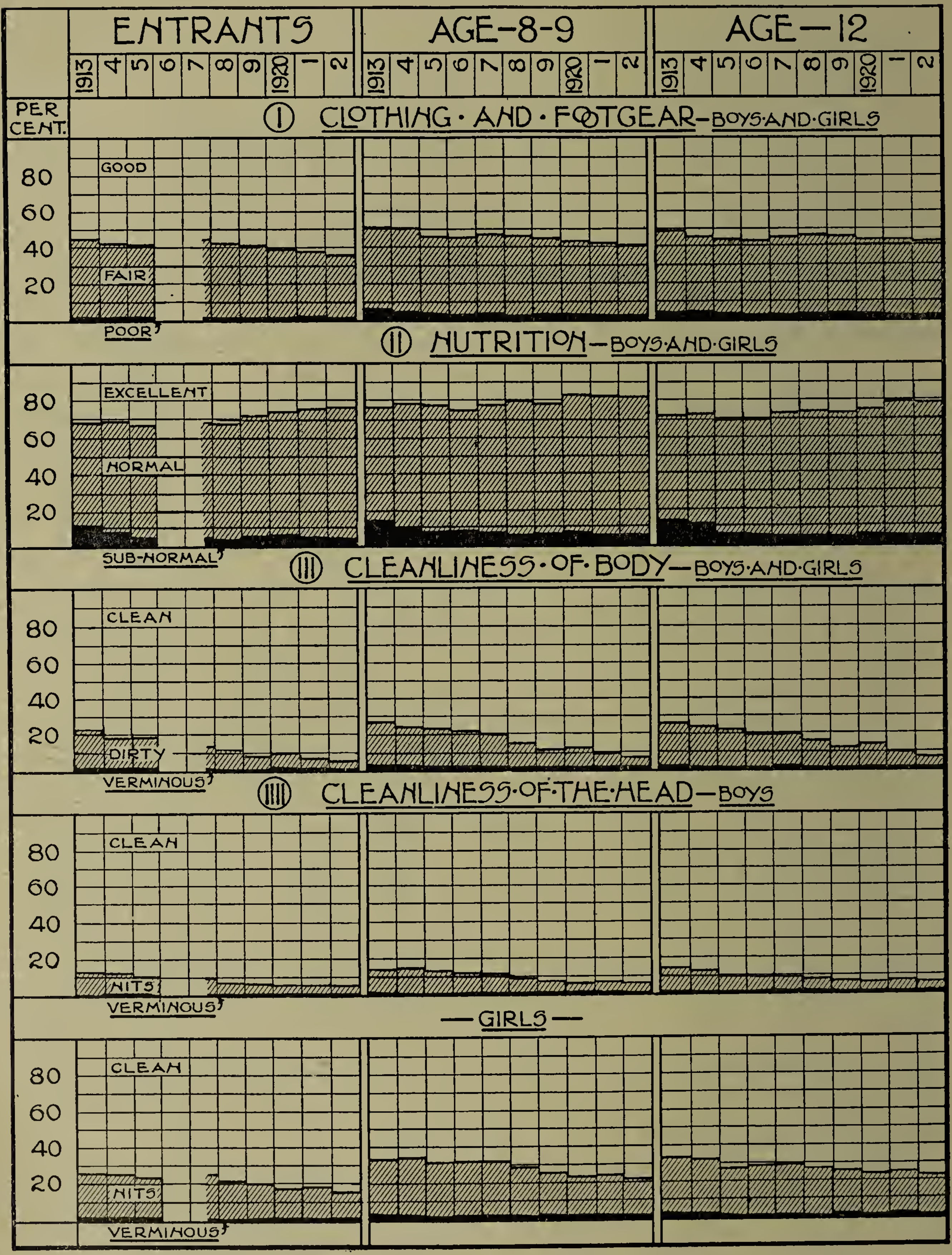

FIG. 92.—Diagram showing general conditions found at Routine Medical Inspections of School Children, London, 1913–1922.

Each section of the diagram is divided into areas representing the proportion of children classed in three different grades..

County Council (General Powers) Act, 1922, to include bugs, fleas, lice and itch mites and their eggs, larvæ and pupæ.

Neglect—Reference has been made to the question of the prosecution of negligent parents for allowing their child to come to school in a verminous condition. Under Section 12 of the Children Act, 1908, a parent or guardian is also liable to prosecution if he neglects a child " in a manner likely to cause injury to his health " by failing to provide " adequate food, clothing, medical aid, etc." or if, being unable to provide such, he fails to take steps to procure the same to be provided under the Acts for the relief of the poor. Under this section education authorities, the National Society for the Prevention of Cruelty to Children, and others, prosecute parents, who, from indifference, obstinacy, or other reasons, fail to carry out treatment of defects discovered at the school medical inspection. Defective vision, defective teeth and enlarged tonsils and adenoids are the defects chiefly concerned, but, in general, this section gives, great power to education authorities to prevent necessary treatment being withheld from defective children through the carelessness or obstinacy of their parents. Experience has shown that a prosecution followed by a conviction has a salutary effect in an area where treatment " hangs fire." Section 3 of the Local Education Authorities (Medical Treatment) Act, 1909, relieves a parent from the obligation of submitting a child to treatment *by the education authority* but does not relieve him of his liability under Section 12 of the Children Act, 1908.

School Dental Service—The care of the teeth is of prime importance, and an increasing number of education authorities are alive to the importance of establishing dental treatment schemes. The percentage of children requiring dental treatment, in some degree, is probably not far short of 80. Treatment is practically always carried out at the authority's own clinics—hospital treatment being rare. In rural areas dental caravans may be successfully employed. A dental clinic necessitates a waiting-room, a treatment-room and a recovery-room. The full equipment necessary for a dental clinic can be obtained in portable form, so that in county areas it is not necessary to equip each dental clinic separately.

The number of registered dental practitioners in this country falls much below the national requirement, even allowing for the effects of the Dentists' Act, 1921, and dental dressers may be employed by education authorities under the supervision of registered members of the dental staff. Such persons may be dental students, dental nurses, or others—each group being limited to partly qualified or trained persons as prescribed by regulations. The work of these dressers is limited to temporary fillings, scaling, charting, and the like.

Where a dental service is not adequate attention should be devoted in the first instance to children in the 6–8 years' group, to re-examinations, and to emergency work, relief of pain, treatment of oral sepsis, etc. The 6–8 years' group is chosen to ensure the supervision of the eruption of the permanent teeth and the overhaul of the temporary or deciduous teeth in preparation therefor. Fillings in the temporary teeth should not be elaborate—a filling of a temporary nature or dressing with nitrate of silver is sufficient.

School dentistry should be primarily preventive, then conservative —fillings, scaling, extractions for conservative purposes, regulation work, etc. As a general rule nitrous oxide gas should be used for extraction work.

The preventive work of the school dentist should include talks to children, parents and teachers, the promotion of tooth-brush clubs, especially in infants' departments and hints on diet, *e.g.*, the harmful effect on the teeth of sweets, the beneficial effect of raw apples and so on.

Infectious Diseases—Infectious diseases and the control of epidemics form an important problem in connection with all schools, and particularly elementary schools. The school population, especially in infant schools, is largely unprotected by acquired immunity; there is every opportunity for the spread of infection because of the close contact of the children themselves, often in inadequately ventilated schoolrooms, and of the interchange of pens and other equipment ancillary to education.

The diseases which occur most frequently in schools in epidemic form are measles, whooping-cough, scarlet fever, diphtheria, chicken-pox, and minor conditions—ophthalmia, ringworm, scabies and impetigo.

The influence of school attendance in connection with diphtheria prevalence was demonstrated, in 1876, at Brailes, by W. H. Power; and Thorne Thorne, in 1877, noted that in an outbreak of diphtheria at Coggeshall, children at school age had been specially affected. Power, in 1882, investigated an outbreak of diphtheria which occurred at Pirbright, and showed, from consideration of the behaviour of the disease during periods of school closure, and again during periods when the school was open, that "conditions of school attendance played an important part in the speciality of the incidence of grave illness on children three to twelve (years of age) in Pirbright." Other outbreaks were from time to time investigated by inspectors of the Local Government Board, and it was found "that apart from age and susceptibility, 'school influence,' so-called, tends to foster, diffuse, and enhance the potency of diphtheria, and this, in part at least, by the aggregation of children suffering from that 'sore throat' which commonly is prevalent, antecedent to and concurrently with, true diphtheria." The suggestion was made that, under certain favouring conditions, there might "be a progressive development of the property of infectiveness" (Thorne Thorne).

In 1884 an Article was inserted in the Code of Regulations of the Committee of Council on Education dealing with the question of school closure, and a Memorandum on the subject of "School closure and exclusion from school of particular scholars as means for controlling spread of infectious disease" was issued, in the same year, by the Local Government Board. This "School Memorandum" was re-issued in 1890, 1909 and 1925.

The administrative action which has gradually evolved may take the form of school closure, class closure, or the exclusion of selected children (Article 53(*b*) of the Code, 1922).

School closure for a specified time is "a measure that seldom ought to be enforced except in presence of an actual epidemic, nor even then as a matter of routine, nor unless there be a clear prospect of preventing the propagation of disease, such as could not be looked for from less comprehensive action." The Board of Education states that "there is a consensus of medical opinion that, as a general rule, the best method of preventing the spread of infection during an epidemic is the careful exclusion of individual children. School closure in exceptional circumstances may be ordered by the school medical officer (Article 45(b)) or the medical officer of health in his capacity as such. The medical officer of health if not also school medical officer may order the closure of the school on the authority of two members of the sanitary authority (Article 57) or on his own certificate if countersigned by the school medical officer.

The Memorandum of 1890 specifies the diseases principally requiring action as those which spread by infection directly from person to person, such as scarlet fever, measles, diphtheria, whooping-cough, small-pox, and rubella. It lays down the universal principle that all children suffering from any dangerous infectious disorder should be excluded from school until they have ceased to be infectious. Furthermore all children of an infected household should be excluded, and sometimes the attendance of children from a particular street or hamlet may with advantage be prohibited; school interests may, of course, be more particularly considered in the case of diseases involving little or no danger to life, such as mumps and skin diseases.

A summary of the London County Council regulations as regards exclusion of infected children and contacts from School is shown on the next page.

The following points may be noted in connection with the table of exclusion periods :—

Scarlet Fever—Exclusion of infected children should continue until all sore throat, discharges from the ear and nose, and enlargement or suppuration of glands, have ceased. In Brighton the minimum period of exclusion fixed is at least 9 weeks.

Diphtheria—Bacteriological examination should be required in the case of both infected children and contacts—in the case of the latter to eliminate possible "carriers." The "Code of Rules" issued by the Medical Officers of Schools Association advises three successive negative bacteriological examinations of nose and throat at intervals of not less than two days, each examination being made not less than three hours after the discontinuance of local antiseptics; this is for sufferers and contacts alike.

Table of Exclusion Periods

(Summary of L.C.C. Regulations, 1925).

Disease.	Children suffering from the Disease.	Children Living in Houses where the Disease exists.
Small-pox . . .	After discharge from Hospital.	16 days.
Scarlet Fever Diphtheria	(1) If treated at home—14 days after disinfection of house or (2) 14 days after discharge from Hospital.	(1) 7 days from disinfection of house or (2) 14 days from certification if removed to Hospital.
Poliomyelitis . . .	(1) Until certified free from Infection or (2) After discharge from Hospital.	May attend unless M.O.H. or S.M.O. certifies otherwise.
Encephalitis Lethargica	Until recovery. [6 weeks at least.]	May attend.
Measles	At least 3 weeks from date of appearance of rash.	*Infants* until Monday following 14 days from incidence of *last* case. *Seniors.* If child has had Measles—may attend. If not, as for infants.
German Measles . .	One week from date of rash—if medically certified. Otherwise as for Measles.	As for Measles.
Mumps	7 days from subsistence of swelling.	May attend but should be carefully watched.
Whooping-cough .	While cough continues and not less than 6 weeks from onset.	*Infants.* 21 days from onset of *last* case. *Seniors.* If child has had Disease—may attend. If not, as for Infants.
Chicken-pox . . .	14 days or until all traces of scabs have disappeared.	As for Whooping-cough.
Scabies . . . Impetigo . . . Ringworm . . Influenza . . .	Until cured or recovered.	May attend.

Head Teachers should be required during outbreaks of scarlet fever or diphtheria to notify the M.O.H. of any of their scholars who suffer from sore throat or sore nose or swollen cervical glands.

Measles—Contacts liable to exclusion are sometimes excluded for 21 days from the onset of the last case in the house. In Brighton there is no routine exclusion of such contacts.

Chicken-pox—In many areas no contacts are excluded.

German Measles—Provided a medical certificate is furnished, in Brighton contacts are not excluded.

Head Teachers are usually required to notify all cases of infectious disease among their scholars coming to their notice. In Brighton mumps and chicken-pox are only required to be notified if they seriously interfere with the school attendance.

Mumps—Some areas exclude contacts for three weeks, others allow the children to attend under close observation.

Whooping-cough—In many areas the patient is excluded for six weeks from the commencement of the illness. In Brighton in the case of infants a period of eight weeks is fixed.

Cerebro-spinal meningitis—Sufferers will not be fit to attend school till three months at least after the onset of the illness.

The Memorandum of 1925 gives a valuable ruling on the employment of tuberculous teachers, caretakers, and other members of the staff. He cannot be employed until he has furnished two consecutive medical certificates: one stating that the disease is quiescent, the other, six months later, stating that the improvement in his general and local physical condition has continued. Further medical certificates are also required after the lapse of one and two years respectively from the date of return to duty. Teachers suffering from pulmonary tuberculosis may be employed in Sanatorium Schools if no risk of injury to the teacher or children would result.

The closing of a school is a much more serious matter than the exclusion of particular scholars. "The mere fact that in an epidemic many of the sufferers are school children does not necessarily show that the disease was caught at school; but the school may, with probability, be regarded as spreading infection if, in a large majority of households attacked, the first case be a child attending school; and with still greater probability if a number of children living at a distance from one another, and with no circumstances in common, except that they attend the same school, should be simultaneously attacked, and if it can be ascertained that a child or teacher in an infectious state has actually been attending the school."

In the Memorandum of 1890, the subject of alternative powers is thus discussed:—

"In deciding whether an outbreak of infectious disease among children of school age may be best combated by closing the school, or whether it will suffice to exclude the children of infected households, the two most important points to be considered are—

> "The completeness and promptness of the information received by the officers of the sanitary authority respecting the occurrence of infectious cases.
>
> "The opportunities which exist for intercourse between the children of different households elsewhere than at school."

"The more prompt and full the knowledge of cases of infectious disease that the sanitary authority are able to obtain, the better will be the prospect of checking such disease by keeping away from school the children of infected households, and the less will be the necessity for closing schools. If the cases be few in number, and their origin known, the exclusion from school of the children of infected households will probably suffice, but this measure will fail where there are many undiscovered or unrecognised cases, or where the known centres of infection are peculiarly numerous. Commonly, the failure of carefully considered measures of exclusion to stay the spread of an epidemic which shows a special incidence upon school children may be regarded as pointing to the continued attendance at school of children with the prevalent disease in a mild or unrecognised form, and a strong case will appear for the closing of schools. If, by reason of the absence or exclusion of a large number of children, the attendance at a school be greatly reduced, it may be found better to close it altogether. This is especially apt to occur in the case of epidemics of measles, a disease which is very infectious in the early stages, before the characteristic rash has appeared, and while the symptoms resemble those of a common cold."

"The second material consideration in deciding as to the desirability of closing schools during the prevalence of infectious disease is the amount of opportunity for inter-communication between the members of different households elsewhere than at school. In sparsely populated rural districts, where the children of different households, or of separate hamlets, rarely meet except at, or on their way to, the village school, the closing of the school is likely to be effectual in checking the spread of disease.[1] It is less likely to be useful in a town or compact village (particularly where houses are sub-let and yards are in common), where the children of different households, when not at school, spend their time in playing together, and often run in and out of each other's houses.[2] In some such places the closing of schools has even appeared to do harm rather than good. In rural districts, where epidemic diseases are less frequently prevalent, school closing may be required as an exceptional measure to meet an exceptional state of things. As regards more populous places, it must not be forgotten that if schools were to be closed whenever infectious disease was prevalent, there are many places where schools would hardly ever be open."

The Memorandum refers to the importance of mutual aid being rendered by school authorities and health officers.

The absence of power of control over Sunday and private schools is pointed out.

The Memorandum of 1909 was issued in order to deal with the altered position arising under the Administrative Provisions Act of 1907 under which the School Medical Officer was introduced into the local administrative machinery of preventive medicine. The Memorandum of 1925 effects certain further changes. The main point emphasized is that "*if during epidemics of infectious disease, the power to exclude individual children from school be used to the best advantage, it is only in special and quite exceptional circumstances that it will be necessary to close a school in the interests of public health.*" It is further stated that hitherto "it has been possible for Education Authorities to close schools during the prevalence of epidemics of infectious disease not purely in the interests of public health but on financial grounds, in order to prevent loss of grant owing to the lowered attendance of children at such times." In future under the amended Article 45 (*b*) of the Order when Authorities close schools on the advice or with the approval of their School Medical Officer such advice or approval shall only be "*given on the ground that such closure is necessary for medical reasons*" : a further amendment secures authorities against financial loss when schools are kept open with a greatly lowered attendance.[1]

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[1] Owing to improved means of transport the opportunities of personal contact are now greater in these rural schools and school closure has lost much of its efficacy.

[2] It is to be observed, however, that the close aggregation of children in the class-rooms of public elementary schools does not find any parallel in the conditions of home or street life. But the aggregation in cinemas and often in Sunday schools is as great.

COMMON SCHOOL AILMENTS

Ringworm of the scalp is moderately contagious ; spread occurs when the spores of the fungus are transferred from the head of one child to another by direct contact or by means of hairbrushes, combs, caps or bed linen. In some instances the disease is contracted at the barber's ; a larger number are caused by children wearing the hat or cap of a child suffering from the disease ; the disease is most frequently spread during the intimate contact of a "rough and tumble" or by sleeping in the same bed.

In Brighton it was found that about one-third of the children belonging to the same family as a sufferer were also infected. The disease in children dies out when they reach 16 years. Diagnosis and the termination of the disease are best established by the microscopic examination of the hair stumps.

Provided they wear a cap or hat and a suitable ointment is applied daily, no spread occurs when children with the disease are allowed to attend school, an advantage in the case of so chronic a complaint. If cure does not follow a trial of two to three months with ointments, the head should be exposed to X-rays, when epilation of all the hair including the ringworm stumps takes place within about three weeks of the exposure.

Ringworm of the skin is readily cured in every public elementary school child ; in country districts it is sometimes contracted from animals, especially cattle.

Favus is rare in this country ; it is found chiefly among Polish Jews and Russians, who have contracted the disease in their own country. X-ray treatment has proved very efficacious.

Scabies is often spread by infected bed linen. Cleansing stations are of much service in the treatment of this disease among the poorer classes. If one member of a family is found to be suffering, all the other members of the family should be examined and all those infected treated at one time by hot baths and thorough scrubbing of the affected parts in order to soften the skin and open the burrows, followed by patient inunction of a sulphur ointment of the strength of 1 in 15, or alternatively with the gentle but thorough rubbing of the body with lint steeped in Liq. Calcis sulphuratæ freshly prepared. Whilst the hot baths are being taken the patients' clothes and bedding should be disinfected. All children with sores between fingers, on the wrists, or behind the knees should be suspected.

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[1] See also rule 23. When the attendance of a school or department has fallen below 60 per cent. (or some other figure determined by the Board) of the number of children on the registers and the Local Education Authority are satisfied by a certificate from the school medical officer that the fall in the attendance to so low a percentage may reasonably be attributed to the presence of epidemic illness in the district, the meetings and attendances for the period during which the attendance is below 60 per cent. need not be reckoned in calculating the average attendance for the purpose of the Board's grant and the matter will be adjusted.

The external eye affections commonly seen in school children include marginal blepharitis, phlyctenular conjunctivitis, the slightly infectious angular conjunctivitis, caused by the Morax-Axenfeld bacillus, and the very infectious micro-purulent conjunctivitis, due to Koch-Weeks' bacillus, and spread in schools by the common use of roller towels.

Trachoma is rarely seen in English children; most of these cases occur in the children of foreigners. It is found in Russia, Poland, Southern Europe, Egypt and Ireland, and in the United States of America, both among the native and foreign population. Trachoma is a disease of poverty spread by the massing together of large numbers of people in badly ventilated houses without the possibility of maintaining personal cleanliness. The disease is incurable unless recognised in its early stages and even then cure can only be obtained as the result of treatment over a long period. Trachoma is very contagious, the infective material contained in the discharge being conveyed from eye to eye as in other infectious eye diseases by dirty fingers, soiled towels, handkerchiefs, bed linen, and wash basins contaminated with the disease, etc. Flies spread the disease in hot countries. Trachoma was formerly rife in residential Poor Law Schools. Nettleship fully considered the matter in his "Report on Ophthalmia in the Metropolitan Pauper Schools" and he held that "where many persons are herded together, their eyelids show sooner and more certainly than any other part if the conditions of vigorous health are not complied with." The tendency of late years has been to regard the aggregation of large numbers of children in "barrack schools" as a mistaken policy, and with a view to giving effect to the principles of subdivision, the "cottage home" system, as opposed to the large institution system, has in some instances been adopted, or in other cases small independent houses have been erected in place of a continuous pile of buildings, and as far as possible the collection of large numbers of children in common living or sleeping rooms has been avoided.

Much has been done to prevent the spread of infection, from child to child, by setting apart a brush, towel, etc., for the use of each individual, and providing clean water for each child. Again, the fact must not be ignored that some of the ill effects produced by life in institutions have been due, in the past, to errors of diet, and to rigid adherence to ill-regulated and insufficiently varied diet-scales.

Children of Low Mentality—Children whose mentality is subnormal fall into two main groups :—

(*a*) Dull or backward children.

(*b*) Mentally deficient children.

With regard to the first group the Board of Education has, for some years, required school medical officers to ascertain the numbers of backward children in their respective areas.

From these statistics Sir George Newman estimates that there are some 600,000 backward children of school age in England and Wales.

From similar data he estimates that *not less than* 30,000 children are mentally defective.

The causes of backwardness are often removable—late commencement of school attendance, or bad attendance, under-feeding, unsatisfactory environment, ill-health, defective vision, deafness, etc. The group of backward children includes those with inherent mental weakness, and the backwardness may apply to all the subjects of the curriculum or may affect certain subjects only and may indeed be accompanied by more than average ability in other subjects, *e.g.*, sewing, drawing, manual work.

Backward children should be dealt with by the removal of any contributory cause when this is possible and also by special attention in the child's own school or by special classes for individual schools or groups of schools as the numbers require. Manual work occupies a prominent place in such special classes. It is generally recognised that even where special classes exist the backward children should be associated with normal children in some part of the day's work, *e.g.*, singing, games, drill, drawing, etc.

With regard to the second group, the causes of mental deficiency include heredity, alcoholism, syphilis, some aspects of environment, consanguinity of parents, definite illnesses—meningitis, infantile hemiplegia, etc.

The Elementary Education (Defective and Epileptic Children) Act, 1899, gave *powers* to education authorities to ascertain the mentally defective (excluding idiots and imbeciles) children in their areas and to make provision for their education at special schools or otherwise. The amending Act of 1914 turned these powers into duties. Parents are under an obligation to bring their children, if required, for medical examination for this purpose and to contribute to their maintenance at special schools.

The Mental Deficiency Act, 1913, classified mentally defectives as under :—

(*a*) *Idiots*—unable to guard against common physical dangers.

(*b*) *Imbeciles*—not idiots but incapable of managing their own affairs or of being taught to do so.

(*c*) *Feeble-minded*—not imbeciles, but requiring care, supervision and control, and in the case of children permanently incapable of receiving proper benefit from instruction in ordinary schools.

(*d*) *Moral Imbeciles*—persons who from an early age display some permanent mental defect, coupled with strong vicious or criminal propensities on which punishment has had little or no deterrent effect. Their educational attainments are often equal to those of normal children of the same age.

It is the duty of the education authority under this Act to notify to the local control authority all idiots and imbeciles over 7 years coming to their notice; also to notify all feeble-minded children who are incapable of being educated at a special school, and all children who are about to leave a special school of this class who require further institutional treatment or guardianship.

The liability of the education authority is, therefore, to notify certain cases as above, and to provide for the education of the remainder between the ages of 7 and 16.

The results of this education are interesting. Out of large numbers kept under supervision by after-care committees in London and Birmingham, 73 per cent. of the London cases were after training "in employment" or "employable"; in Birmingham, 35 per cent. were "doing remunerative work." These results appear to justify greater effort and expenditure on the training of the mentally defective.

In the diagnosis of mental deficiency, the family and individual history are valuable. Physical characteristics are also of value—microcephaly, hydrocephaly, bossing, asymmetry of the head, abnormality of the palate and teeth, cretinism, mongolism, etc. Mental characteristics—habits, abnormal movements, incontinence, lack of concentration, forgetfulness, moral defects and general educational defects, are, of course, of the greatest importance in the diagnosis.

The tests of Binet and Simon or one of the modifications of these are commonly used for diagnosis and classification.

School Baths—Education authorities obtained powers under the Education Act, 1918, Section 17, to provide school baths or school swimming baths. Unfortunately school bathing provisions in this country, instead of being universal, are quite exceptional, being confined to the larger towns and some progressive smaller authorities.

The most inexpensive form of school bath is the shower bath, with concrete flooring, and these can be provided in adequate numbers along with efficient undressing arrangements comparatively inexpensively if the arrangements are not planned on elaborate lines.

A few large education authorities, including Bradford, Leeds, Liverpool and Brighton, have provided school swimming baths attached to the public elementary schools.

Such baths should always include shower baths for the preliminary cleansing of the children. The educational side of school bathing should always be emphasized.

Where bathing facilities are available, either swimming baths or natural open-air facilities, school medical officers should, at the medical inspections, indicate those children who should not be allowed to join the bathing parties—those with contagious skin diseases, ear disease, heart disease, etc.

School Meals—Under the Education (Provision of Meals) Act, 1906, education authorities were empowered to provide meals for the elementary school children of the area. These meals were only to be provided on days when the schools met and the total cost was not to exceed a halfpenny rate. The formation of canteen committees was authorised. Payment for these meals was to be recovered from the parents except in necessitous cases. The object of the Act was primarily to deal with children who " from lack of food are unable to take full advantage of the education provided."

The Education (Provision of Meals) Act, 1914, extended the provision to school holidays, and other days on which the schools do not meet, and repealed the clause limiting expenditure to a halfpenny rate.

It has always been intended that the meals should be under the general supervision of the school medical officer who should in general select the children to be fed and should direct the choice of diet on scientific lines. The object is scientific feeding of selected children and not indiscriminate charity.

There is a wide diversity in different areas as to the meals provided —both as to the cost, the kind of meal, the standard of necessity, etc. For 1923 the average cost per meal (food and administration) varies in different areas between one penny and one shilling and twopence. Some areas spend in administration twice or thrice what they spend in food, other areas charge nothing for administration—presumably because care committees are available.

The meal most commonly provided is dinner ; if two meals are provided the other may be breakfast, tea or supper. The practice in different areas is about equal as between breakfast and an evening meal, but for the purpose of the Acts—to secure fitness to benefit by education—the advantage in theory, at least, of a morning meal is obvious.

Meals may be provided in the schools themselves, or in halls, etc., if conveniently near. It is no part of the duty of teachers to assist at these meals, though they may do so if they choose—see the Act of 1906, Section 60. Whether they do or not, these meals properly conducted, can be of the highest educational value.

Reference has previously been made to the selection of the children to be fed and it should here be added that although the Acts are primarily intended to apply to malnourished or habitually underfed children easily selected on medical grounds, there are many children to be selected on other grounds. There is the case which, in most county areas (Kent being a notable exception), receives insufficient consideration, of children attending rural schools. These children may come two or three miles to school and even in the worst of the winter their "dinner" consists of what they bring to school, tea and bread and butter, or jam, or the like. It is not claimed that the parents are necessitous—no doubt they would willingly pay for meals if provided. Such children so placed have to contend with (*a*) wet clothes, (*b*) no adequate mid-day meal, and undeniably they suffer in health and physique from these handicaps. When the employment of the parents is precarious, numbers of children—not themselves underfed—may have to be placed under the benefits of the Acts to prevent them becoming so.

Circular 856 of the Board of Education, published in 1914, gives lists of suitable one- and two-course dinners with recipes and quantities. Important points are, that the meals should contain animal proteins and fats in adequate quantity; these more expensive food principles are often deficient in the dietaries of the poor.

The child of 10 years requires about 2 ounces of protein and 1½ ounces of fat daily.

A typical Bradford 2-course dinner (*e.g.*, lentil soup, bread, ginger pudding and sweet sauce) supplied half these quantities, and a breakfast of porridge and milk, with a tea of two slices of bread and margarine and weak tea, with milk, would complete a satisfactory diet.

The matter of vitamins must also receive attention; in the mining areas of Cumberland skin diseases were rampant before school meals were provided. Those diseases completely disappeared in a few weeks thereafter, presumably due to the anti-scorbutic factor in the fresh vegetables freely utilised in the dietary.

To combat the tendency of tradesmen to supply institutions with food of an inferior quality to that supplied to private families, it is always desirable, where school meals are supplied, to have food analysed regularly both with reference to possible adulteration and with reference to food values. This is done, for example, in connection with the school meals supplied by the London County Council.

Physical Exercises and Games—Physical training, properly conducted, is beneficial to physical development, is educational—promoting alertness, accuracy and the sense of discipline, and is recreative. There is definite benefit to the higher nervous system; minimisation of effort due to improved co-ordination gives the sense of increased power and in addition definite strengthening of the will.

The more formal "drill" in use at public elementary schools has gradually been replaced by "physical" exercises, based mainly on the Swedish system,[1] and by games, dancing, swimming, etc.; steps have been taken to ensure the proper teaching of these subjects, facilities—as regards equipment, playing-grounds, etc.—have been widely extended.

The basis of the arrangements is that the instruction in physical exercises, etc., should be given by the class teachers in the elementary schools. Physical training is, therefore, now a compulsory subject in the curriculum of training colleges, while, locally, in the most advanced areas, the work is in the hands of the organisers of physical training who visit the schools and assist the teachers with their classes, and who also hold evening classes for teachers in physical training, dancing, and games.

One of the difficulties in the way of adequate physical training in this country is climatic, as, for a large part of the year, open-air classes are difficult to hold on account of the weather. Proper sheds, well lighted, and with cross ventilation, should, therefore, be provided in every school playground; the commonly provided type of lean-to shed is quite unsuitable. The surfaces of the playgrounds are often quite unsuitable if not actually dangerous.

Local education authorities are empowered by Section 17 of the Education Act, 1918, after having obtained the approval of the Board of Education, to make provision for physical training in its widest sense. They may provide—

(i) Staff, in the shape of organisers for the elementary schools, qualified teachers for secondary schools, remedial gymnasts, etc., and monetary assistance to teachers attending physical training classes.

(ii) Clothing, especially shoes, tunics for girls, etc.

(iii) Covered sheds, properly surfaced playgrounds, gymnasia, playing-fields, remedial clinics, etc.

(iv) Play-centres and equipment for physical recreation, after school hours and on Saturday mornings, facilities for swimming, summer camps, or the subsidy of these (boy scouts, girl guides, etc.).

(v) Similar facilities for children attending continuation classes.

The time allotted in the school curriculum to the subject varies very much. It is desirable that a daily lesson of not less than 20 minutes should be given, with, in the case of the older children, the substitution of one period of 45 minutes weekly for organised games. This programme should be carried out in full in urban, and especially in slum areas.

The association between the school medical service and the physical training department in each area should be close. In some areas the department is definitely under the direction of the school medical officer—an obviously desirable arrangement. The annual reports of organisers should be included in that of the school medical officer.

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[1] The official textbook on the subject is the "Syllabus of Physical Training for Schools," published by the Board of Education in 1919.

Remedial treatment (for spinal curvatures, flat feet, etc.) and re-education are an essential part of a cripple scheme. The treatment of severe cases is unprofitable, and such should be dealt with at orthopædic hospitals. Such deformities, in the early stages, are easily dealt with in classes, preferably at a remedial clinic properly equipped with plinths, wall-bars, etc. These classes are a sound financial proposition as they prevent the deformity, in most cases, from progressing to the hospital stage, which is prolonged and expensive.

Clothing for physical exercises should be loose; in boys, coats, collars and waistcoats should be removed, and belts should be worn rather than braces. In the case of girls tight dresses, corsets and garters should be avoided. The modern loose dress of the average girl is not unsuitable, but tunics, with a blouse or jersey and dark knickers, is the most suitable dress. In place of corsets, liberty bodices, or similar bodices should be worn. The idea is that the clothing should be suspended from the shoulders and not from the waist. Well-fitting shoes allow free movement of the feet.

Exercises should, whenever possible, be in the open-air, if not in the playground, in a well-ventilated shed, gymnasium or hall. When the weather is wet and the children cannot be taken outside, the period may profitably be employed in the case of the older children in *teaching* proper positions, and the more difficult exercises, and in the practice, with all means of ventilation fully utilised, of deep breathing exercises, and of such general exercises as the desks allow to stimulate the circulation.

The physical training lesson should be given in the morning, when also, in general, the more difficult subjects in the curriculum should be taught. In the case of infants the daily 20 minutes should be split up into two 10-minute periods, the morning one for exercises, the afternoon one for games.

Very young children should practice deep breathing in the course of the exercises given, *e.g.*, running, and not as separate exercises.

Organised games, and inter-school matches are more applicable to older children, especially in secondary schools. The general teaching of these should not be sacrificed, as is sometimes the case, to the training of one or two teams. The games, especially in the case of older girls, require careful supervision, and the medical officer should be frequently in consultation with the head teacher on individual cases.

In the case of children who may be generally delicate or may have definite defects, *e.g.*, heart affections, it is usually preferable to *limit* rather than to *forbid* games and exercises. To allow, for example, free-standing exercises, organised games in less strenuous positions, *e.g.*, goal in the case of hockey, doubles rather than singles at tennis, is better for the child's health and mentality than to debar the boy or girl from normal participation in the activities of the other children.

The exercises themselves may roughly be divided into *massive* movements, involving the use of groups of muscles or of the whole body and *co-ordination* movements. The two groups, of course, overlap. Co-ordination movements are not suitable for very young children.

The tables in the syallabus are so arranged that the whole body is exercised in rotation, the exercises being grouped as follows :—Introductory, Head and Neck, Arm and Shoulder, Balance and Leg, Lateral Trunk, Jumping, Breathing.

EMPLOYMENT OF CHILDREN

Children in employment are safeguarded by the Factory and Workshop Act, 1901, the Employment of Children Act, 1903, and the Education Acts, 1902 and 1918, the Employment of Women, Young Persons and Children Act, 1920, and especially by by-laws made under the Employment of Children Act, 1903 and the Education Act, 1918. By this legislation the protection of children from injurious effects of employment has gradually been secured.

The legislation provides :—

(*a*) that no child under 12 years of age shall be employed for gain.

(*b*) that no child under 14 years of age shall be employed in street trading or in any industrial undertaking or on a ship,[1] except one in which only members of the same family are employed.

(*c*) that during the school term no child shall be employed later than 8 p.m., and earlier than 6 a.m., or for more than one hour before 9 a.m., and if so employed only for an additional hour in the afternoon.

(*d*) that an education authority may prohibit any child, on medical grounds, from being employed in any particular work, or indeed employed for gain in any work.

Child employment is now mainly confined to the delivery of milk, newspapers, shop parcels, caddying on golf courses, and amounts to little more than healthy exercise.

Any school child before he is employed must obtain a certificate from the school medical officer that the employment will not be prejudicial to his health or education. In this connection the sections of the Employment of Children Act, 1903, which require that a child shall not be employed in any occupation likely to be injurious to his life, limb, health, or education, regard being had to his physical condition and " A child shall not be employed to lift, carry, or move anything so heavy as to be likely to cause injury to the child," are suggested for consideration.

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[1] This is defined in Article 1 of Schedule 1 of the Employment of Women, Young Persons and Children Act, 1920, and excludes transport of articles by hand.

A light burden for a well-developed child may be grossly injurious to one of equal age but of poor physical development ; a more satisfactory basis is a standard proportion between the body weight and the weight to be carried. A proportion suggested as suitable by Auden is one-third of the body weight for boys and one-fifth for girls.

Until Section 8 (1) of the Education Act, 1918 (which does away with any exemption from school attendance under 14 years of age), comes into force, where school attendance by-laws provide for the daily or partial exemption of children from school attendance provided that they are shown to the satisfaction of a local education authority to be beneficially employed and that they have satisfied the prescribed conditions of previous due attendance, children may continue to claim exemption under these provisions, but the Board of Education hopes that local education authorities will scrutinise with care any claim to exemption based on the alleged beneficial character of employment.

When Section 14 of the Education Act, 1918, comes into force, no child under the compulsory age for school attendance may be employed in any factory or workshop to which the Coal Mines Act, 1911, and the Metalliferous Mines Acts, 1872 and 1875, apply, unless lawfully so employed on the appointed day.

Section 13 (2) of the Education Act, 1918, amends the Prevention of Cruelty to Children Act, 1904, with special reference to licences for public performances by children, raising the ages at which and the conditions under which licences may be granted, or children allowed to offer anything for sale.

The supervision of employed children is a definite charge on the school medical service. All employed children should be examined as " specials " on the occasion of the doctor's visit to the school for routine medical inspection.

Choice of Employment—Closely allied to the employment of school children is the matter of the employment of children on leaving school. Under the Labour Exchanges Act, 1909, and the Education (Choice of Employment) Act, 1910, the school medical record of the child may become an extremely important factor in deciding what trade or employment will be followed on leaving school. Power is conferred on education authorities to assist boys and girls under 17 years of age " with respect to the choice of suitable employment."

The authority may appoint a juvenile employment officer whose duty it is to interview employers, school medical officers, head teachers, etc., and generally to co-ordinate the efforts to place children who are leaving school in suitable employment.

In some areas, notably London, after-care committees give great assistance in this work.

So far as the medical aspect is concerned there should be close co-operation between the school medical officer and the factory surgeon.

Nursery Schools—Education authorities are empowered to establish " nursery " schools and classes for children over 2 years and under 5 years and to attend to the health, nourishment and physical welfare of the children attending.

These schools are primarily " health " schools and are specially valuable in slum areas. There are some 24 such schools, of which approximately half are in London.

Medical Examination in Secondary Schools—Following the passing of the Education Act, 1918 (see Section 18), medical inspection of secondary schools has now become general. The procedure follows generally the lines of that in the elementary schools, except that the age-groups differ. Children should be examined on admission, and at the ages of 12 and 15. All children should be superficially examined annually, and visits to those schools should, if possible, be made once a month. Treatment, as a rule, is obtained privately, but the benefits of the authority's treatment schemes for elementary children should, in general, be available for exceptional groups of defects and for necessitous cases.

The main difference between the examination of elementary schools and higher grade schools, continuation classes, etc., lies in the supervision of the advent of adolescence, especially in girls, and of the reaction of the children to the increased strain of longer hours, preparation for examinations and train journeys.

KENNETH FRASER.

CHAPTER XV

SANITARY ADMINISTRATION AND SANITARY LAW

Local Authorities—England and Wales are divided under the Local Government Act, 1894, into *administrative counties* and *county boroughs* ; the former (with the exception of the county of London) are further divided into *county districts, urban and rural.* Further, under Section 287 of the Public Health Act, 1875, the Local Government Board may, by order, constitute any sanitary authority or combination of authorities, whose district or districts abut upon a port, a *port sanitary authority.*

The authority in the area of an administrative county is the county council, first brought into existence by the Local Government Act, 1888. The county council may make by-laws for certain purposes, may appoint one or more medical officers of health, and may make complaint to the Local Government Board under Section 229 of the Act of 1875, in cases in which any sanitary authority within the county is not doing its duty. Copies of periodical and special reports must be sent by medical officers of health of districts within the county to the county council. The county council has powers under the Rivers Pollution Act, and the Isolation Hospitals Acts, and it is an " appeal authority " under the Local Government Act, 1894.

County councils and county borough councils are concerned with the administration of the Midwives Acts, with school medical work, maternity and child welfare and with the tuberculosis and venereal disease treatment work in their areas. The Housing Acts, 1909–20, have given new powers to county councils.[1]

In county boroughs the town council, in other boroughs the municipal council, and in urban districts the urban district council, act as sanitary authorities and enforce any local sanitary acts or the general code of legislation to be presently referred to. In rural districts the rural district council is the sanitary authority ; its powers differ to some extent from those of an urban authority. Thus, urban authorities have somewhat wider powers than rural authorities, though, with the approval of the Local Government Board, most of these "urban powers" may be also exercised by rural authorities. Thus, the power to make by-laws as to nuisances, new buildings, offensive trades and slaughterhouses, and authority to adopt the Public Health Acts Amendment Act, 1890, are frequently sought and obtained. Again, Part I of the Housing of the Working Classes Act does not apply to rural districts. On the other hand, the Public Health Water Act, 1878, applies to rural and not to urban districts.

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[1] Maternity and child welfare work has added also to the responsibilities of rural and urban district councils and school medical work to that of many urban district councils and borough councils.

To the urban and rural district councils were allotted, in 1894, the functions previously performed by the urban and rural sanitary authorities, created in 1875. The Local Government Act, 1894, however, further created new authorities, called parish councils, in every rural parish with a population exceeding 300; and in the event of certain preliminaries being complied with, in smaller parishes also. A few sanitary powers devolve upon parish councils, *e.g.*, power to utilise wells and springs, to deal with ponds, pools, ditches, drains, etc.; they may, moreover, hire lands for allotments, and they may make complaint, to the county council, of default on the part of the rural district council, and to the medical officer of health of the district council, concerning unhealthy dwellings. The question of the desirability of putting in force in the parish certain "Adoptive Acts" (Baths and Washhouses Acts, etc.) must be decided by the parish meeting. The powers of expenditure of the parish council, apart from expenditure in connection with "Adoptive Acts," are limited by the condition that not more than a threepenny, or, with the consent of the parish meeting, a sixpenny rate may be incurred. The parish council may raise money on loan, but only with the consent of the parish meeting, the county council and the Local Government Board.

The rural district council remains, however, the sanitary authority in the rural parishes within its area, but it may appoint parochial committees, selected from the members of, or composed of the entire parish council. The Local Government Board has prescribed the duties which may properly be delegated to a parochial committee as being those of periodical inspection as to need of works of construction or of abatement of nuisances, of superintendence of works of construction, of examination and certification of accounts, and of reporting to the district council upon matters requiring attention and upon the performance of the duties of the officers of the council.

In London the council of the administrative county has, in addition to the ordinary powers of other county councils, other functions in connection with health administration. Such are the special powers exercised under the Housing of the Working Classes Act, 1890, the Public Health (London) Act, 1891, and the Common Lodging Houses Acts; there are also licensing and by-law making powers inherited from the Metropolitan Board of Works. The London

Government Act, 1899, constituted borough councils, in replacement of the vestries and district boards, which were, up to that time, the local sanitary authorities in London. Under the same Act considerable alterations of the boundaries of the local areas, with amalgamation of some of them into larger areas, were made, and certain powers of enforcing by-laws, regulations, etc., were transferred from the county council to the borough councils. In London the hospital-providing authority is the Metropolitan Asylums Board, a body distinct from the county and borough councils.

Medical Officers of Health—Liverpool was the first town to appoint a Medical Officer of Health in 1847, under the Towns Improvement Clauses Act of that year, and the Corporation of the City of London, under a special Act, made a like appointment in the following year. Other towns gradually followed the example of Liverpool and the City of London.

Qualifications, Tenure of Office, etc.—The Public Health Act, 1848, empowered local boards of health to appoint a legally qualified medical practitioner as medical officer of health, and the Public Health Act of 1875 imposed upon sanitary authorities generally throughout the country the duty of appointing such officers. Section 18 of the Local Government Act, 1888, requires that a medical officer of health appointed after the 1st January, 1892, to a district having at the last census 50,000 inhabitants or more, shall be the registered holder of a diploma in public health, or have been, during three consecutive years prior to 1892, a medical officer of a district with a population, at the last census, of not less than 20,000, or have been for not less than three years a medical officer or inspector of the Local Government Board.

In cases in which a portion of the salary of the medical officer of health was paid out of Imperial funds the Local Government Board, under the Act of 1872, were given the same powers as those they possessed in the case of district medical officers of unions with regard to appointment, duties, salary, and tenure of office. Regulations with regard to these matters were first issued by the Board in 1872. These regulations have from time to time been amended, and the Local Government Act of 1888 transferred to the county and borough councils the liability, to repayment of salary from Imperial revenue, if claimed by the local authority.

The duties of a medical officer of health are identical whether a contribution is made to his salary or not. County councils may refuse to pay any contribution in the event of their not receiving copies of reports required to be sent to the Local Government Board, to which they are entitled. When no part payment is made the authority may fix the salary at any sum they please, and may remove the medical officer from office at their pleasure. If, on the other hand, part payment is made, the local authority may suspend the officer, but the Local Government Board have power to remove the suspension.

The Duties of Medical Officers of Health were fully set out by the Local Government Board in the Sanitary Officers (outside London) Order, 1910.[1] In somewhat modified form, these instructions apply also to port medical officers, " ships " being substituted for houses, other necessary corrections of a like character being made, and reference to offensive trades being omitted.

Port medical officers, however, have special duties of an important character in acting as the first line of defence against the importation of dangerous infectious diseases, and in connection with unsound food.

The statement of duties given below does not apply to the medical officer of health of a county council, for whom an Order was made in 1910, which will be given separately. A separate statement was also made for port medical officers.

Duties of Medical Officer of Health

County Boroughs, Municipal Boroughs, Urban or Rural Districts.

Article XIX.—The following shall be the duties of the Medical Officer of Health in respect of the District for which he is appointed ; or if he is appointed for more than one District, then in respect of each District :—

(1) He shall inform himself as far as practicable respecting all influences affecting or threatening to affect injuriously the public health within the District.

(2) He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the District, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

(3) He shall by inspection of the District, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

(4) He shall be prepared to advise the Council on all matters affecting the health of the District, and on all sanitary points involved in the action of the Council ; and in cases requiring it, he shall certify, for the guidance of the Council or of the Justices, as to any matter in respect of which the Certificate of a Medical Officer of Health or a Medical Practitioner is required as the basis or in aid of sanitary action.

(5) On receiving information of the outbreak of any infectious or epidemic disease of a dangerous character within the District, he shall visit without delay the spot where the outbreak has occurred, and inquire into the cause and circumstances of such outbreak, and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which appear to him to be required to prevent the extension of the disease and shall take such measures for the prevention of disease as he is legally authorised to take under any Statute in force in the District or by any Resolution of the Council.

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[1] See also Memorandum on Duties of Medical Officers of Health, issued March, 1925, which gives a useful index to the statutes, orders, regulations, and circulars relating to the powers and duties of the M.O.H.

(6) Subject to the instructions of the Council, he shall direct or superintend the work of the Inspector of Nuisances in the way and to the extent that the Council shall approve, and on receiving information from the Inspector of Nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps as he is legally authorised to take under any Statute in force in the District, or by any Resolution of the Council, as the circumstances of the case may justify and require.

(7) In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the Council he shall himself inspect and examine any animal, carcass, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, and any other article to which the provisions of the Public Health Acts in this behalf apply, exposed for sale, or deposited for the purpose of sale or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be dealt with by a Justice according to the provisions of the Statutes applicable to the case. He shall also take such action as it may be necessary for him to take by virtue of the provisions of the Public Health (Regulations as to Food) Act, 1907, and any Regulations made thereunder.

(8) He shall perform all the duties imposed upon him by any by-laws and regulations of the Council, duly confirmed where confirmation is legally required, in respect of any matter affecting the public health, and touching which they are authorised to frame by-laws and regulations.

(9) He shall inquire into any offensive process of trade carried on within the District, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

(10) He shall attend at the office of the Council or at some other appointed place, at such times as they may direct.

(11) He shall from time to time report in writing to the Council his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the District. He shall in like manner report with respect to the sickness and mortality within the District, so far as he has been able to ascertain the same.

(12) He shall keep a book or books, to be provided by the Council, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon and of any action taken on previous reports; and shall produce such book or books, whenever required, to the Council.

(13) On Monday, the Ninth day of January, One thousand nine hundred and eleven, and on every Monday thereafter, he shall forward Us by post, at such an hour as in the ordinary course of post will ensure its delivery to Us on the following Tuesday morning, a return, in such form as We from time to time require, as to the number of cases of infectious disease notified to him during the week ended on the preceding Saturday night. He shall also forward at the same time a duplicate of the return to the Medical Officer or Officers of Health of the County or Counties in which the District is situated.

(14) He shall as soon as practicable after the Thirty-first day of December in each year make an Annual Report to the Council, up to the end

of December, on the sanitary circumstances, the sanitary administration, and the vital statistics of the District.

(15) He shall forthwith report to Us any case of Plague, Cholera, or Small Pox, or of any serious outbreak of epidemic disease in the District which may be notified to him, or which may otherwise come or be brought to his knowledge, [and in the case of a County District, shall also notify the Medical Officer of Health of the County].[1]

(16) He shall transmit to Us three copies of each annual report and one copy of any special report. At the same time that he transmits to Us the copies of his annual report or of any special report, or that he reports to Us a case of Plague, Cholera, or Small Pox, he shall transmit a copy of the report or give the like information to the County Council or County Councils of the County or Counties within which the District is situated. Where the Medical Officer of Health is appointed by the Council of a County Borough, or by a Council having delegated powers under the Midwives Act, 1902, he shall also transmit to the Privy Council and to the Central Midwives Board either a copy of his annual report or of that part of it which contains the statement relating to the administration of the Midwives Act, 1902.

(17) In matters not specifically provided for in this Order, he shall observe and execute any instructions issued by Us, and the lawful orders and directions of the Council applicable to his office.

(18) Whenever We shall make regulations and shall declare the regulations so made to be in force within any area comprising the whole or any part of the District, he shall observe such regulations, so far as the same relate to or concern his office.

The County Medical Officers of Health (Duties) [1] Order, 1910, is as follows :—

(1) The Medical Officer of Health of the County shall inform himself as far as practicable respecting all influences affecting or threatening to affect injuriously the public health in the County. For this purpose he shall visit the several County districts in the County as occasion may require, giving to the Medical Officer of Health of each County district prior notice of his visit, so far as this may be practicable.

(2) The Medical Officer of Health of the County shall, from time to time, inquire into and report upon the hospital accommodation available for the isolation of cases occurring in the County
   (*a*) of small-pox, and
   (*b*) of other infectious diseases,
and upon any need for the provision of other hospital accommodation.

(3) The Medical Officer of Health of the County shall communicate to the Medical Officer of Health of a County District within the County any information which he may possess as to any danger to health threatening that district.

(4) The Medical Officer of Health of the County shall consult with the Medical Officers of Health of County Districts within the County, whenever the circumstances may render this desirable.

(5) If the Annual or Special Reports of the Medical Officer of Health of a County District in the County shall not contain adequate information in regard to
   (*a*) the vital statistics of the district,
   (*b*) the sanitary circumstances and administration of the District, and
   (*c*) the action taken in the District for putting in force the provisions

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[1] Sanitary Officers Order, 1922.

of the Housing and Working Classes Acts, 1890 to 1909, the Medical Officer of Health of the County shall obtain from the Medical Officer of Health of the County District such further information on these matters as the circumstances may demand.

(6) The Medical Officer of Health of the County shall, when demanded by Us, or by the County Council, or as occasion may require, make a special report to the County Council on any matter appertaining to his duties under this Order.

(7) The Medical Officer of Health of the County, shall, as soon as practicable after the Thirty-first day of December in each year, make an Annual Report to the County Council up to the end of December on the Sanitary Circumstances, the Sanitary Administration, and the Vital Statistics of the County.

(8) The Medical Officer of Health for the County shall send to Us two copies of his Annual Report and two copies of any Special Report; he shall also send one copy of his Annual Report to the Council of every County District in the County and shall send three copies of any special report to the Council of every such County District affected by the special report.

The Sanitary Officers Order, 1922, formally revoked all previous Orders dealing with the duties and tenure of office of sanitary officers and re-stated them in a consolidated form.

The medical officer of health should keep a careful record of all his proceedings; he should endeavour to obtain early information concerning any unusual outbreak of illness in his district. He should see that the necessary steps are taken for securing the weekly returns of registered deaths, which, under Section 28 of the Births and Deaths Registration Act, 1874, a sanitary authority may, on payment, procure from the district registrar, and for obtaining returns of registered births and of deaths in outlying institutions. He should arrange that immediate notice should be given him " of all deaths from infectious diseases in fresh localities, and all groups of deaths from such disease, or from diarrhœa in any localities." By an Order of February 12th, 1879, of the Local Government Board, district and workhouse medical officers (and, by a later Order, medical officer of district schools) were required to furnish the medical officer of health with returns of pauper sickness and deaths, and to notify to him the outbreak of any dangerous infectious disease. If any such disease occur on canal boats, in common lodging-houses, or (if special by-laws have been made by the authority) in tenement houses or in tents or vans, the fact must be notified to the medical officer of health.

The extension of compulsory notification of infectious diseases to the general population of the whole country, by the Act of 1899, has placed valuable and much-needed information in the hands of medical officers of health, but the other sources of information specified are likely still to prove of use, and early knowledge of outbreaks of infectious illness is especially necessary for the undertaking of prompt preventive measures. Valuable aid may be afforded, for example, in this connection, where the co-operation of school authorities is secured. Most useful information is also obtained from the weekly return of notified infectious diseases occurring in sanitary districts in England and Wales.

Certain useful census data, over and above the published particulars, can be obtained with the consent of the Registrar-General. The population, for example, of "enumeration" districts is ascertained at the time of the census, but in the census tables these enumeration districts do not appear, the smallest areas dealt with being the "registration sub-districts," each of which may include a number of enumeration districts. When questions arise concerning local prevalences of disease, or the rate of mortality observed in specially unhealthy areas, knowledge of the population of individual enumeration districts may be of great value, and it is desirable, therefore, to have this information ready to hand.

Annual Reports—The Local Government Board has from time to time issued Memoranda (with appended explanatory tabular forms) concerning the preparation of annual reports. It has been pointed out by the Board that the report should, in order to secure uniformity, be in all instances for the year ending December 31, and that it should be completed, if possible, within six weeks, and at latest within three months, of the end of the year to which the report relates. Indications have already been given under the Sanitary Officers Orders, 1910, as to what the annual reports should contain.

The following is a skeleton account of what the Report should contain as prescribed in the Memorandum.

Natural and Social Conditions of the District—Population, physical features, social conditions, including occupation.

Sanitary Circumstances of the District—

Water supply—Sufficiency, source, liability to contamination.
Rivers and Streams—Presence or absence of pollution.
Drainage and Sewerage—Character and sufficiency in all parts.
Closet accommodation—Approximate number of closets of different types.
Scavenging—Character and efficiency of the arrangements, number of movable ashbins with proper covering.
Sanitary Inspection of the District, including the Annual Report of the Inspector of Nuisances, the number of notices served by him, and the result.
Premises and occupations which can be controlled by By-laws or Regulations.
Other conditions requiring note.
Schools—Their sanitary condition and water supply. Action taken for the health of the scholars in respect of infectious diseases and otherwise.

Food—

(*a*) *Milk Supply*—Its condition and supervision. Milk and Cream Regulations, 1912 and 1917, action under. Milk (Mothers and Children) Order, 1919. A review of the action taken.

(*b*) *Meat*—Meat inspection, condition of slaughterhouses, provision of a public abattoir and provision for inspection of meat at slaughter, action taken under Sec. 117, P.H.A., 1875, or Sec. 47 of the P.H. (London) Act, 1891. Tabulated statement as regards slaughterhouses in the district, registered or licensed.

(*c*) *Other foods*—Unsound foods of other kinds. Condition of bakehouses or other premises where food is manufactured, prepared, stored, or exposed for sale.

(*d*) Cases of food poisoning in the district.

Prevalence of, and Control over Infectious Diseases—In addition to the ordinary infectious diseases, special attention is directed to Tuberculosis, on which full detailed particulars are requested. The following diseases also require notice: Cerebro-spinal Fever, Encephalitis Lethargica, Pneumonia, Malaria, Dysentery and Trench Fever. The report should deal with the prompt use of diphtheric antitoxin and with the subject of "return" cases of Scarlet Fever, also with other diseases of importance, with the subject of contacts, and the condition and performance of vaccination. The arrangements for isolation and disinfection should be given. The action taken to discover and deal with "contacts" should be stated.

Venereal Diseases—Full particulars and discussion should be given of the Council's Scheme.

Maternity and Child Welfare—The action on this subject should embrace

(1) Action taken under the Midwives Acts.

(2) Full particulars in respect of the work of the Maternity and Child Welfare Scheme.

(3) On the incidence of and administration regarding puerperal fever, ophthalmic neonatorum, measles, whooping-cough, epidemic diarrhœa, poliomyelitis, and other infectious diseases of parturient women, infants and young children.

Sanitary Administration—

(1) Staff. Work of Sanitary Inspectors and other Officers.

(2) Hospital accommodation available for infectious diseases.

(3) Local Acts, Special Local Orders, or general Adoptive Acts in force and their administration.

(4) Arrangements for chemical and bacteriological Reports during the year 1919, and their results (including examinations of material for detection of tubercle bacilli).

Any report by the public analyst which it may be considered desirable to append.

Other Services—*Housing*—Full particulars are required as regards housing accommodation; conditions in respect of overcrowding, general character of housing in the district; number of houses regarded as unfit for human habitation and action taken in regard to them; proceedings under the Housing and Town Planning Acts, 1909 and 1919, representation of unhealthy areas; action taken under the Housing Regulations, 1910; by-laws relating to houses, houses let in lodgings, and to tents, vans, sheds, etc.

Every fifth year the annual report is to be a survey report indicating the measure of progress made in the area in the preceding five years in the improvement of the public health and the extent and character of the changes made during that period in the public health services of the area and any further action contemplated to develop the work.

Sanitary Inspectors—In London, sanitary inspectors appointed after January 1st, 1895, must be certificated, a saving proviso being made for existing inspectors. Sanitary inspectors appointed or re-appointed after April 1st, 1922, if they come within the scope of Part III of the Sanitary Officers Order, 1922, must also be certificated. In Scotland no medical officer, *or sanitary inspector* . . . can be removed from office without the sanction of the Scottish Local Government Board. By the Public Health (Officers) Act, 1921, whole time Medical Officers of Health and Senior Sanitary Inspectors in England and Wales (with certain exceptions mentioned in Circular 299, based on the absence of a contribution to the salary from county or imperial funds), cannot be removed from office without the sanction of the Ministry of Health.

In large county boroughs, sanitary inspectors will be divided into general districts inspectors, and others occupied with special branches of the work, such as Food and Drugs, Smoke, Workshops, Drainage, Milkshops, Houses let in Lodgings, Common Lodging Houses, etc. In small districts a sanitary inspector may have to take on the duty of surveyor.

The duties of a sanitary inspector, which include those discharged in a large county borough by the senior inspector and those discharged by a district inspector (which in a small district correspond to those of the sole inspector), are set out in the Sanitary Officers Order, 1922.

Duties

19. The Sanitary Inspector as regards the District or part of the District for which he is appointed shall—

(1) perform under the general direction of the Medical Officer of Health all the duties imposed on a Sanitary Inspector by statute and by orders, regulations and by-laws for the time being in force lawfully made by the Local Authority or by the Minister or his predecessors, and observe and execute any directions or instructions of the Local Authority or of the Minister applicable to his office;

(2) by inspection of his District both systematically and at intervals as occasion requires, keep himself informed of the sanitary circumstances of the District, and in respect of the nuisances therein that require abatement;

(3) report to the Local Authority any noxious or offensive businesses, trades, or manufactories established within his District, and the breach or non-observance of any by-laws or regulations made in respect thereof;

(4) report to the Local Authority any damage done to any works of water supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used or intended to be used for domestic purposes;

(5) from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the preparation or sale of any article of food to which the provisions of the statutes and regulations in that behalf apply, and examine any article of food therein, and take such proceedings as may be necessary:

Provided that in any case of doubt arising under this paragraph, he shall report the matter to the Medical Officer of Health, with the view of obtaining his advice thereon;

(6) give immediate notice to the Medical Officer of Health of the occurrence within his District of any infectious or epidemic disease or other serious outbreak of illness; and whenever it appears to him that the intervention of such Officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house or of any other conditions affecting the health of the District, forthwith inform the Medical Officer of Health thereof;

(7) if directed by the Medical Officer of Health to do so, remove, or superintend the removal of, patients suffering from infectious disease to an infectious diseases hospital, and perform or superintend the work of disinfection after the occurrence of cases of infectious disease;

(8) if so directed by the Local Authority, supervise the scavenging of his District or any part thereof;

(9) if so directed by the Local Authority, act as Officer of the Local Authority under the Diseases of Animals Acts, 1894 to 1909, the Canal Boats Acts, 1877 and 1884, the Rats and Mice (Destruction) Act, 1919, and under any Orders or Regulations made thereunder;

(10) enter from day to day, in a book or on separate sheets or cards provided by the Local Authority, particulars of his inspections and of the action taken by him in the execution of his duties;

(11) at all reasonable times, when applied to by the Medical Officer of Health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of Sanitary Inspector relate;

(12) as soon as practicable after the 31st day of December in each year, furnish the Medical Officer of Health with a tabular statement containing the following particulars:

   (*a*) the number and nature of inspections made by him during the year;

   (*b*) the number of notices served during the year, distinguishing statutory from informal notices;

   (*c*) the result of the service of such notices.

Where in any District there shall be two or more Sanitary Inspectors, nothing in this Order shall be deemed to prevent the Local Authority from distributing among them the duties directed by this Order to be performed by a Sanitary Inspector.

Sanitary Law

In succeeding paragraphs the Public Health Act, 1875 (38 & 39 Vict., c. 55), will be cited as the Act of 1875. Other Acts will be referred expressly to.

Sewerage and Drainage—Section 13 of the Act of 1875 provides that all existing and future sewers, with the exception of certain private sewers, shall be vested in the local authority, who may, moreover, purchase sewers (Section 14), and shall (Section 15) maintain all sewers belonging to them; further, they must make such new sewers as may be necessary for effectually draining their district, and construct, cover, ventilate, and keep all sewers belonging to them so as not to be a nuisance or injurious to health, and cause them to be properly cleansed and emptied. Section 23 empowers the local authority to enforce drainage of undrained houses, and the drain must communicate with the local authority's sewer, if there be one within one hundred feet from the site of the house, or else with such covered cesspool, or other place, not being under any house, as the local authority direct. The drain, or drains, may be required to be of such materials and size, and to be laid at such level and with such a fall as, on the report of their surveyor, may appear to the local authority to be necessary. In default the local authority may carry out the work and recover their expenses.

Difficulty has arisen in deciding, in certain instances, as to whether a particular channel is a drain or a sewer, and whether, therefore, the private owner or the local authority is responsible for its maintenance, etc. This question has especially forced itself upon attention in connection with "combined drains." Section 4 of the Act of 1875 defines a "drain" to be "any drain of, and used for the drainage of, one building only or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cesspool, or other like receptacle for drainage, or with the sewer, into which the drainage of two or more buildings or premises occupied by different persons is conveyed." "Sewer" includes "sewers and drains of every description, except drains to which the word drain as aforesaid applies, and except drains vested in, or under the control of, any authority having the management of roads, and not being a local authority under the Act of 1875."

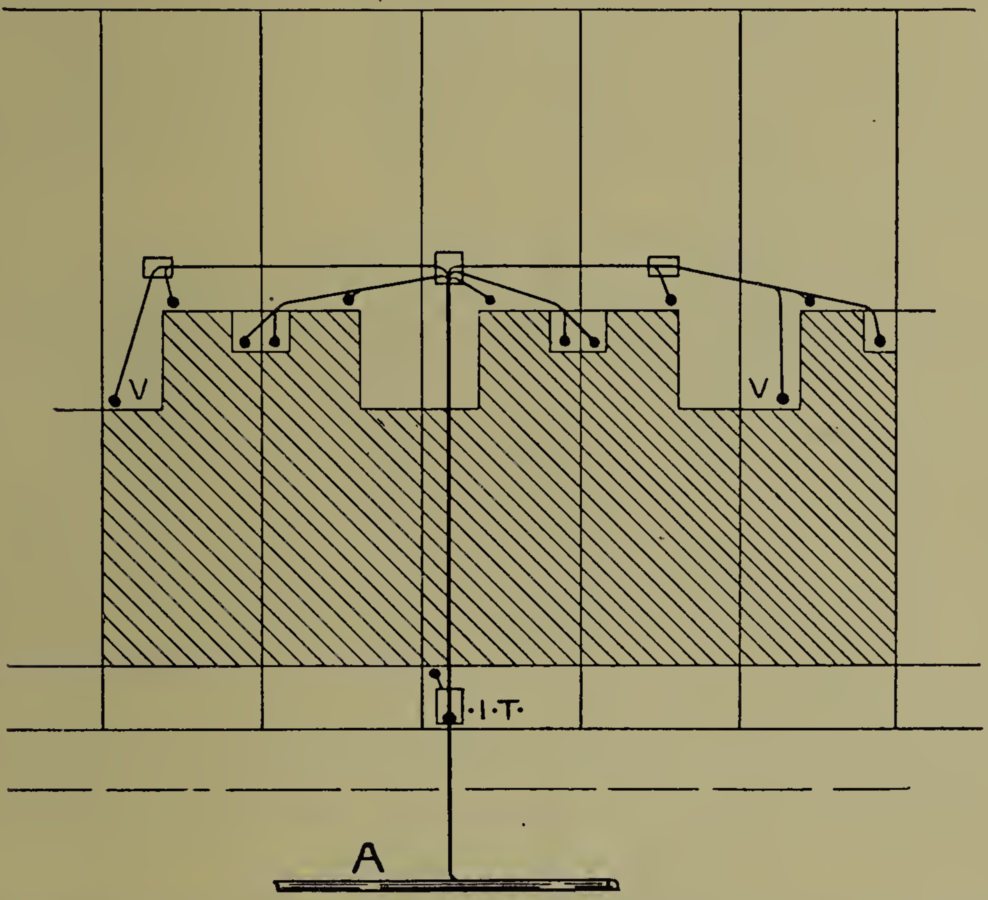

FIG. 93.—Block plan of five houses drained by a combined system of drainage (owner responsible for maintenance) with means for access and ventilation and an intercepting trap between drain and sewer.

The Public Health Acts Amendment Act, 1890, alters the position somewhat, as it throws upon the private owner the cost of executing any necessary works "where two or more houses belonging to different owners are connected with the public sewer by a single private drain." Thus the conduit used for the drainage of more than one building is styled, if the buildings drained by it are in different ownerships, a private drain; if the buildings are in one ownership, it is by implication a sewer.

In London the confusion is, perhaps, even greater, as "drain" is defined (Metropolis Local Management Act, 1855) as including "any drain for draining any group or block of houses by a combined operation under the order of any vestry or district board"; the amending Act of 1862 further extends the definition to combined drains, laid before vestries and district boards became sewer authorities, if made with the sanction or approval of the Metropolitan Commissioners of Sewers. If, however, the combined drain have been laid without sanction or approval at all, or if it have been laid, or repaired, otherwise than upon approved plans, it is a sewer, and therefore repairable by the local authority. A heavy responsibility was thus thrown upon local authorities in connection with the repair of combined drains.

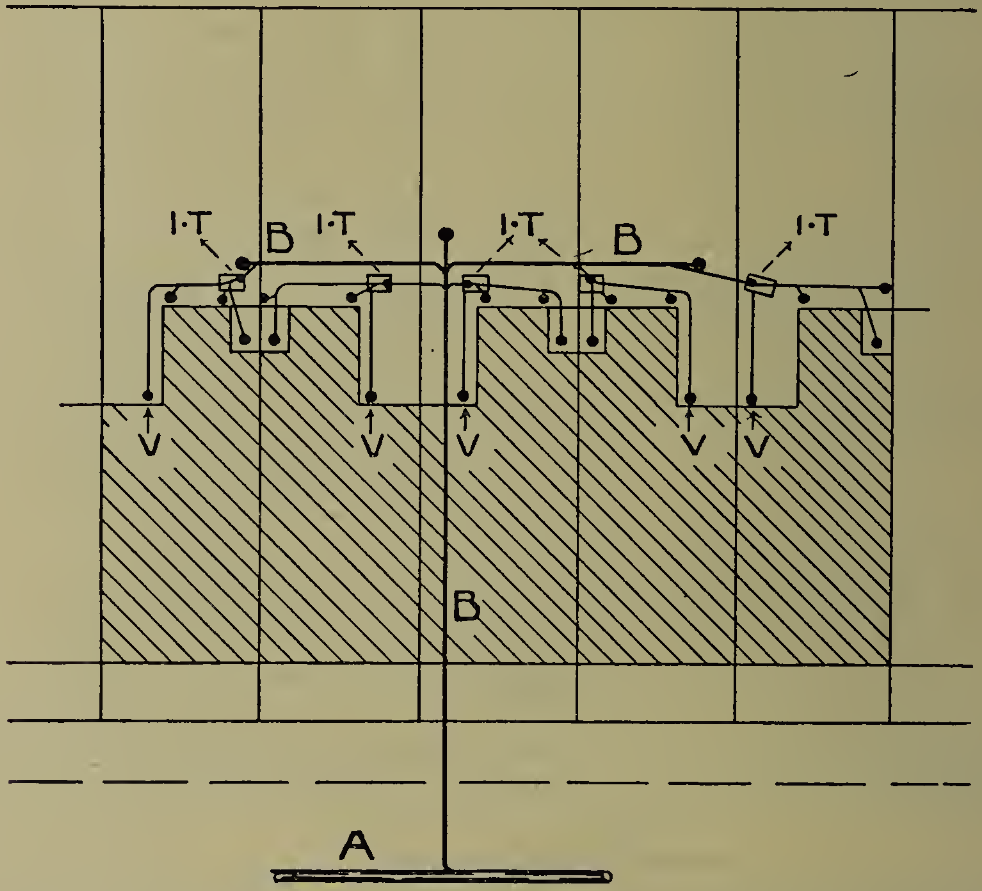

FIG. 94.—Block plan of the same group of houses drained by a pipe which is technically a "sewer," marked B—B—B (Local Authority responsible for maintenance), each house being drained by a separate drain provided with means for ventilation and access and an intercepting trap between drain and "sewer."

Disposal of Sewage—Section 27 of the Act of 1875 gives local authorities powers for disposing of sewage; they may construct works, purchase buildings, materials, etc., and contract to supply any person with sewage, provided that no nuisance is created in the exercise of any of these powers.

The extent to which watercourses became polluted by the sewage works of local authorities led to the passing of the *Rivers Pollution Prevention Act*, 1876. This Act deals not only with solid or liquid sewage matter, but also with solid refuse likely to interfere with the flow of, or to pollute, any stream with poisonous, noxious, or polluting liquid from any factory, or manufacturing process, and with solid matter from mines, likely to prejudicially affect the flow of any stream, and with poisonous, noxious, or polluting solid or liquid matter, proceeding from any mine, other than water in the same condition in which it has been raised or drained from the mine.

In the case of both sewage matters and trade effluents there are saving clauses relating to conditions existing at the time of the passing of the Act, no offence being deemed to have been committed if it is shown, in such cases, that the best practicable and available means of rendering the effluent harmless are being used.

With regard to solid matters and sewage, proceedings can be taken by any private person or local authority aggrieved; with regard to trade and mining effluents, only the local authority can act, and it must obtain the approval, before doing so, of the Local Government Board. Procedure under the Act, has been beset with obstacles, and improvement has only gradually been effected. So far as sewage was concerned, local authorities, being themselves in many instances offenders, experienced difficulty in acting as prosecuting authorities. The 14th Section of the Local Government Act, 1888, considerably advanced matters by giving county councils powers under the Act, and by providing for the constitution by the Local Government Board of joint committees, representing the several counties through which a river, or part of a river, passes, and having the powers of local authorities.

The Public Health Acts Amendment Act, 1890, makes it unlawful to pass into any drain or sewer any substance which may injure it or impede the flow of its contents, or any chemical refuse or waste steam, or water or other liquid heated over 110° F., which alone, or in combination with sewage, causes nuisance or is dangerous or injurious to health.

Privies, Water-closets, etc.—Sections 35 and 36 of the Act of 1875 give the local authority power to enforce the provision, in connection with any house, of a sufficient water-closet, earth-closet, or privy, and an ashpit with proper doors and coverings. The authority may require separate accommodation for the two sexes in factories, etc., and the Act of 1890 makes such provision compulsory in all factories and workshops. Further, the Sanitary Accommodation Order, 1903, made under the Factory and Workshops Act, 1901, defines the amount of accommodation required, and makes provision for the separation of the sexes, for privacy, and for the separation of closets from the workroom. Urban authorities may provide public sanitary conveniences (Section 39 of the Act of 1875), and every authority is required to see that drains, closets, etc., are constructed and kept so as not to be a nuisance or injurious to health (Section 40). Section 41 deals with the examination of drains, closets, etc., on complaint of nuisance, and with remedy of the faulty conditions found, if there be any.

Scavenging and Cleansing—The local authority may, and, if required by the Local Government Board, shall, undertake or contract for the removal of house refuse, the cleansing of earth-closets, privies, ashpits, and cesspools, and the proper cleansing of streets (Section 42). Any person obstructing the removal of the matters above referred to is liable to penalty, and the local authority, if they undertake the work, are made liable to penalty for any delay exceeding seven days in removing refuse, etc., after written notice from the occupier of a house (Section 43). Where the local authority do not themselves undertake such work they may make by-laws imposing the duty of cleansing and removal upon the occupier. Section 46 provides for the purification of a house, in such a filthy or unwholesome condition as to endanger health, on the certificate of a medical officer of health or of two medical practitioners. Section 47 makes it unlawful to keep swine in any urban district so as to be a nuisance and requires removal within 24 hours of waste water in cellars, after written notice from an urban authority, and renders liable to a penalty overflows from water-closets, cesspools, etc.

Sections 48, 49, and 50 provide for the cleansing of offensive ditches, etc., the removal of filth on the certificate of the inspector of nuisances, and the periodical removal of manure from mews, stables, and other premises, and for the prevention of further accumulation.

Water Supply—General powers of supplying water are given to the local authority under Section 51, but they may not construct waterworks within the limits of supply of any company empowered, by Act of Parliament, or any Order confirmed by Parliament, to supply water, so long as the company are able or willing to provide a proper and sufficient supply themselves (Section 52). By Section 55 a local authority shall provide and keep in any waterworks constructed or purchased by them a supply of pure and wholesome water. This requirement entails the making of analyses, chemical and bacteriological, from time to time.

Section 62 empowers the local authority to require that houses without a proper supply, when such supply can be furnished at a cost not exceeding the rate authorised by any local Act, or twopence a week, or such other cost as the Local Government Board may determine, shall be furnished with such supply. By the Public Health (London) Act, 1891, Section 48, an occupied house without a proper and sufficient supply of water is a nuisance. If the house is a dwelling-house, it is to be deemed unfit for habitation.

Section 68 imposes a heavy penalty for causing water to be corrupted by gas washings. Section 69 prescribes the procedure to be adopted for protecting a watercourse from pollutions arising from sewage. Section 70 prescribes the procedure to be adopted for ascertaining and closing polluted wells, tanks or cisterns ; any person may lodge a complaint, on which the local authority may apply to a court for an order to remedy the condition. The court may make an order to close, temporarily or permanently, and in the latter case, may require the local authority to have the water analysed, if analyses have not previously been made, before they make a permanent closing order.

The Public Health (Water) Act, 1878, makes further provision for the needs of rural districts, and of such urban districts as the Local Government Board may order the Act to be extended to. If a house is without a proper water supply, and the authority find that such supply can be provided for a reasonable capital outlay (the interest on which, at 5 per cent., must not exceed 2*d.* a week, or, if the Local Government Board deem it desirable, 3*d.* a week), the owner may be required to provide such supply, and in his default the local authority may carry out the necessary works at the owner's expense.

The provision of a water supply to houses, under this Act, is surrounded with difficulties and delays, the water even when provided may be at an inconvenient distance.

When, however, danger arises from the insufficiency or unwholesomeness of an existing supply, and a general scheme of supply is required, and can be carried out at a reasonable cost, it is the duty of the local authority to carry out such scheme themselves. At times it may require considerable ingenuity to show that the cost is reasonable. Further, no house in future erected or rebuilt is to be occupied under the terms of the Act without a certificate from the local authority that it has a sufficient supply of wholesome water.

Cellar Dwellings—No cellar, vault, or underground room built or rebuilt since 1848 can be occupied separately as a dwelling (Section 71), and no cellar whatsoever can be so occupied unless it complies with the following requirements (Section 72) :—

" (i) It must in every part be seven feet high, and at least three feet of its height must be above the surface of the street or the ground adjoining or nearest to it.

(ii) An open area at least two feet six inches wide must extend, from six inches below floor level, along the whole frontage of the cellar. This area may be crossed by steps, provided they are not opposite the cellar window.

(iii) There must be an efficient drain, the uppermost part of which is at least a foot below the level of the floor.

(iv) There must be appurtenant to the cellar a proper closet and ashpit.

(v) There must be a fireplace and a proper flue, and a window at least nine square feet in area, made to open. In the case of a back cellar, let or occupied, with a front cellar, the window need only be four square feet in area."

Section 74 provides that any cellar in which any person passes the night shall be deemed to be occupied as a dwelling within the meaning of this Act. It must be noted, however, that it is only suffering the cellar to be occupied *separately* as a dwelling that is prohibited, and if the cellar is let with other rooms there is nothing to prevent its being used as a sleeping-room. Section 75 provides that, when two convictions regarding separate occupation of a cellar have taken place within three months, a court of summary jurisdiction may order the cellar to be closed for such a time as it deems fit, or may empower the local authority to permanently close the same.

By Section 7 of the Housing and Town Planning Act, 1909, a room habitually used as a sleeping-place, the surface of the floor of which is more than three feet below the surface of the part of the street adjoining or nearest to the room, shall be deemed to be a dwelling-house unfit for human habitation, unless the room is on an average seven feet in height from floor to ceiling and complies with regulations made by the local authority, with the consent of the Ministry of Health, regarding such rooms. Draft regulations have been prepared by the Ministry of Health.

Common Lodging-Houses are dealt with in Sections 76–89 of the 1875 Act. The Amendment Act of 1890 contains, moreover, a section (32) rendering a keeper liable to penalty who fails to give notice of any case of infectious disease as required by Section 84 of the Act of 1875. In London the original Common Lodging-Houses Acts of 1851 and 1853 were in force till 1902, when the Act of 1851 was repealed by the L.C.C. (General Powers) Act, 1902. These Acts were administered by the Police Commissioners until 1894, when the duty was transferred to the London County Council. The Acts contain many of the provisions which are operative throughout the country generally. In the Public Health (Scotland) Act, 1897, certain important provisions relating to common lodging-houses were for the first time introduced—notably, such houses were made subject to annual licence: again, a common lodging-house was defined (Section 3) as " a house or part thereof where lodgers are housed at an amount not exceeding fourpence per night for each person" ; with the approval of the Local Government Board, the limit fixed may be diminished or raised, but not so as to exceed sixpence.

The English Acts contain no definition of a common lodging-house. The law officers of the Crown, in 1853, advised that the term applied "to that class of lodging-houses in which persons of the poorer class are received for short periods, and, though strangers to one another, are allowed to inhabit one common room," but not to "hotels, inns, public-houses, or lodgings let to the upper and middle classes." In a later opinion it was explained that the phrase "strangers to one another" was meant to distinguish "lodgers promiscuously brought together from members of one family or household" ; and, further, question having been raised as to whether letting for a week or longer period would exclude houses otherwise within the definition, the law officers stated that they regarded the "period of letting" as "unimportant in determining whether a lodging-house comes under the Act now in question."

Several important decisions have in recent years been given as regards the interpretation of the term "common lodging-house." In Langdon *versus* Broadbent, in 1878, the principle was laid down that, in deciding whether a particular house was a common lodging-house, regard should in each case be given to the consideration whether the circumstances of occupation were such that supervision by the local authority was necessary in order to secure cleanliness, ventilation, good-ordering, etc.

In Booth *versus* Ferrett, 1890, it was held that a Salvation Army shelter, not carried on for profit, was not a common lodging-house. In 1899 the London County Council, however, raised question with regard to the use of certain premises, among which was included "The Harbour," Stanhope-street, Strand, a Salvation Army shelter. A summons was dismissed on the ground that "The Harbour" was a charitable institution, and that the facts were not distinguishable from those in Booth *versus* Ferrett. The decision in this case (Logsdon *versus* Booth) was appealed against, and judgment was given in favour of the Council by the Lord Chief Justice in 1899.

The Lord Chief Justice pointed out that "the learned judges in Booth *versus* Ferrett came to the conclusion (but with hesitation) that a similar house —— —— was not a common lodging-house on two grounds. First, that it was not carried on as a business for the sake of profit, but as a humane or charitable enterprise ; and second, that it was not open to all comers, as, it was stated, a common lodging-house was. With regard to the first contention, it was noteworthy "that the Acts of 1851 and 1853 are sanitary Acts," and that their object is to secure, by inspection and control, for the poor in these houses "conditions safeguarding health and preventing the spread of disease, which people better off are supposed to be able to secure for themselves." Again, the question was not "with what object or with what motive the house is carried on, but whether the house is such, or is so carried on as a lodging-house, as to be within the provisions of the Act, as it is clearly within the mischief aimed at by the Act." "We fail," Lord Russell said, "to see the relevance in this connection of the motive actuating the keeper of such a house whether it be philanthropic or mercenary." Coming now to the second contention, the need of distinguishing, between receiving all comers without discrimination, and saying that the keeper is under an obligation to receive all comers, was pointed out; in fact, it was found in the case of "The Harbour" that practically all comers were admitted. The conclusion was therefore arrived at that Booth *versus* Ferrett was wrongly decided.

A further test case, Logsdon *versus* Trotter, was also decided in favour of the Council in 1900. Here a point was raised (in connection with a dormitory divided up by partitions) with regard to the words, "allowed to inhabit one common room." The decision given was that the house was a common lodging-house, inasmuch as the inmates were "allowed so to associate with one another as to make the danger of insanitary conditions likely to arise and likely to spread."

Section 76 of the Act of 1875 requires every urban and rural authority to keep a register of common lodging-houses, and Section 77 prohibits lodgers being received in unregistered houses. Section 78 empowers the authority to require a certificate of character from the keeper, and provides that before a house is registered it must be "inspected and approved for the purpose by some officer of the sanitary authority." For the principles which should guide the "approving officer" see p. 293. Section 79 requires a notice of registration to be affixed to the common lodging-house if the sanitary authority demand it. Section 81 deals with the provision of proper water supply, and Section 82 with periodical lime-washing. Section 83 gives power to order reports on schedules supplied by the local authority, from keepers of houses of vagrants received during the preceding day or night. Section 84 requires the keeper to give notice of fever and infectious disease occurring in the house. Section 88 provides that, where the keeper is convicted of a third offence under the Act, the court may, if it thinks fit, prohibit him, for a period not exceeding five years, from keeping a common lodging-house without a licence from the sanitary authority. Under Section 80 the duty is imposed upon the authority of making by-laws for the purpose of supplementing the provisions of the act. Part V of the Public Health Amendment Act, 1907, made applicable only after an order of the Ministry of Health, contains further provisions, the adoption of which entails report of part of Section 78, and of Section 88, of the Public Health Act, 1875.

The local authority may refuse under the Act of 1907 to register any person as a keeper, unless satisfied as to his character, and his fitness for the position; registration of all new keepers is to remain in force not longer than one year. Proper control must be exercised by the presence either of the keeper or his deputy. More than one deputy may be registered with power to cancel. On conviction of a keeper of an offence under the provisions of the Public Health Acts or the by-laws relating to common lodging-houses the court may cancel his registration. A person keeping a common lodging-house without registration shall be subject to all provisions as if registered. Every lodging-house is to provide sufficient and suitable sanitary conveniences (with proper separate accommodation for the sexes), and with sufficient flush for any water-closets or urinals.

Common lodging-houses are regulated in Scotland by the Public Health (Scotland) Act, 1897 ; the provisions are similar to those in the English Public Health Acts, except that (*a*) the keepers of the common lodging-house are registered annually, (*b*) the making of by-laws is optional, (*c*) the local authority on the closure or isolation of a common lodging-house on account of infectious disease may supply accommodation and maintenance. The provisions of the London County Council (General Powers) Act, 1902, are similar to those of the Public Health (Scotland) Act, 1897. A keeper of a common lodging-house is subject to annual license. The London County Council may make regulative by-laws.

Houses let in Lodgings—By-laws under Section 90 of the Act of 1875 were only operative in districts which had been empowered, by the Local Government Board, to make by-laws. Section 8 of the Housing of the Working Classes Act, 1885, made the preliminary empowerment unnecessary, but proposed by-laws must still receive the approval of the Ministry of Health.[1]

Nuisances—" Whatsoever unlawfully annoys or does damage to another is a nuisance," says Blackstone, and he instances stopping " ancient light " as a private nuisance, and placing a gate across a public highway as a common or public nuisance. In addition to such " nuisances at common law," there are the special " statutory nuisances," which either cause, or are likely to cause, injury to health, and which come within the scope of the Public Health Acts. Certain kinds of nuisance are referred to in special sections of the Act of 1875 (*e.g.*, Sections 18, 19, 27, 40, 41, 49, and 50, relating to sewers, drains, etc.) ; Section 44, dealing with snow, dust, etc. ; Section 46 gives power on the certificate of the medical officer of health, to whitewash, cleanse, or purify a house in a filthy or unwholesome condition ; Section 47 regulates the keeping of animals ; and deals with prompt removal of waste or stagnant water in a cellar, and with overflow from privies ; Sections 112–114 are concerned with offensive trades ; there is, further, the general nuisance section (Section 91), which defines a number of other conditions likely to injure health as being " nuisances," which can be dealt with summarily under the Act. These conditions are :—

(1) Any premises in such a state as to be a nuisance or injurious to health :

(2) Any pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit, so foul or in such a state as to be a nuisance or injurious to health :

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[1] See also p. 747.

(3) Any animal so kept as to be a nuisance or injurious to health :

(4) Any accumulation or deposit which is a nuisance or injurious to health :

(5) Any house, or part of a house, so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family.

(6) Any factory, workshop, or work-place (not already under the operation of any general Act for the regulation of factories or bakehouses) not kept in a cleanly state, or not ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance or injurious to health, or so overcrowded while work is carried on as to be dangerous or injurious to the health of those employed therein.

(7) Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam or in any mill, factory, dyehouse, brewery, bakehouse, or gasworks, or in any manufacturing or trade process whatsoever ; and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such a quantity as to be a nuisance, shall be deemed to be nuisances liable to be dealt with summarily in the manner provided by this Act.

Two saving clauses must be specially noted in connection with the above. First, there is no liability to penalty under the heading (4) if it is shown that the accumulation or deposit is necessary for, and " has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health." Secondly, as regards (7), the complaint if made under the first part of Section 91 (7), shall be dismissed if it is proved that the fireplace or furnace is " constructed in such manner as to consume as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having the charge thereof." There is a further saving clause contained in Section 334, which relates to mines, the smelting of ores and minerals, and the calcining, puddling, etc., of iron.

Later Acts have extended the definition of the term " nuisances." Thus, filthy and overcrowded tents and vans are included under the Housing of the Working Classes Act, 1885 ; unfenced quarries by the Quarry Fencing Act of 1887 ; and abandoned coal mines by the Coal Mines Regulation Act of the same year. Section 2 of the Public Health (London) Act, 1891, substitutes, it should be noted, for the words " a nuisance or injurious to health " the words " a nuisance or injurious or dangerous to health."

Section 16 of the Public Health (Scotland) Act, 1897, also includes as "nuisances" any premises, *or part thereof of such a construction*, or in such a state, as to be a nuisance; any well or water supply; any deposit of offensive matter (other than farmyard manure or spent hops from breweries) within 50 yards of any public road, or standing at any railway station, siding, or in canal boats; any schoolhouse or any factory not subject to the Factory and Workshops Acts, 1878–1895, in respect of cleanliness, ventilation, and overcrowding; and any churchyard or cemetery so situated or so crowded, or otherwise so conducted as to be offensive or injurious or dangerous to health.

Section 92 of the Public Health Act, 1875, makes it the duty of the local authority to cause their district to be inspected for the detection of nuisances. Sections 189 and 190 require that every urban authority shall appoint one, and every rural authority one or more inspectors of nuisances. Section 93 provides that information of any nuisance may be laid by any person aggrieved thereby, by any two inhabitant householders, or by any officer of the authority, the relieving officer, or a police-officer in the district. Section 94 deals with the service of notice, to abate the nuisance within a time specified and to execute such works as may be necessary for the purpose (specified), upon the person "by whose act, default, or sufferance the nuisance arises or continues, or, if such person cannot be found, on the owner or occupier of the premises on which the nuisance arises." If the nuisance result from some structural defect the notice must be served on the owner, and where the person causing the nuisance cannot be found, and the nuisance does not arise or continue by the act, default, or sufferance of the owner or occupier of the premises, the local authority may themselves abate the same without further order. Section 255 relates to nuisance caused by the act or default of two or more persons.

Section 95 provides that if the person on whom the notice is served, makes default in complying with any of the requisites of the notice or if the nuisance though abated is likely to recur, the local authority shall cause a complaint of such nuisance to be laid before a justice, who shall thereupon issue a summons on the defaulting person to appear before the court.

Section 96 provides that the court adjudicating upon the alleged nuisance, in the event of non-compliance with the notice of the authority, may make an abatement order or an order prohibiting the recurrence of the nuisance, non-compliance with which involves liability to penalty; the order may direct the execution of works, and must then specify that works are necessary. In cases where the nuisance renders a dwelling unfit for human habitation a closing order may be made; this order may be determined when the dwelling has been rendered habitable: there is an appeal to quarter sessions against the order of the court. Section 102 gives power of entry to the local authority or its officers for the purposes of examining as to the existence of any nuisance. In case of refusal complaint must be made on oath by an officer of the local authority to a justice, who, after due notice given to the keeper in charge of the premises—that it is intended to lay a complaint—may make an order for admission.

Section 107 relates to cases in which the local authority elect to institute proceedings for the abatement of nuisance in the High Court of Justice under circumstances in which it is thought summary proceedings will not afford an adequate remedy. Section 108 gives power to proceed where the cause of nuisance arises without the district; Section 110 contains a special provision as to ships or vessels within the district of a local authority, which are made subject to the same jurisdiction as if they were houses within such district or within that district which nearest adjoins. Other important nuisances are:—

(1) Those arising from flies due in towns to accumulation of horse manure and other accumulations producing flies, which may be dealt with either under Section 91 Public Health Act, 1875, or under by-laws under Section 44, P.H.A., 1875. The latter are defective in so far as they do not require removal of the accumulations outside the area, or their destruction.

(2) Damp in buildings dealt with by the Public Health (Amendment) Act, 1907, Section 35.

(3) Nuisances due to rats, dealt with under the Rats and Mice (Destruction) Act. Further powers are required prohibiting the exposure of food material to rats.

(4) Body vermin. Further powers are required. Additional powers have been obtained in London under the L.C.C. General Powers Act, 1922 (Section 9).

In the event of the local authority failing to take proceedings there are three courses open to any aggrieved individual. Under Section 299 complaint may be made to the Local Government Board that the local authority has made default, and the Board, if satisfied that the complaint is well founded, may make an order, enforceable by mandamus, requiring the authority to perform the duty within a specified time. This method of proceeding is cumbersome, and the authority when required to take action under compulsion is not likely to take pains to demonstrate that its previous neglect to do so was unjustifiable. A second course of action is that provided for under Section 106, which empowers the Local Government Board to authorise any officer of police acting within the district of the defaulting authority to institute the proceedings and to recover the expenses from the authority. Here, again, the procedure is cumbersome, and the police-officer, although not directly interested in the failure of the proceedings, has no interest in their success. The third course is that contemplated by Section 105, which enables any person aggrieved, or any inhabitant of the district, or any owner of premises within the district, to institute proceedings. The section provides that the court may adjourn the case, if necessary, for examination of the premises to be made, and may authorise the entry of any constable or other person for the purposes of such examination. Such constable or person may further execute any order made by the court, and recover expenses from the person on whom the order is made. In London and in county districts there is, it should be noted, provision for making complaint to the county council in case of default on the part of the local authority.

Offensive Trades—Section 112 of the Act of 1875 defines offensive trades as being those of "blood boiler, bone boiler, fellmonger, soap boiler, tallow melter, or tripe boiler, or any other noxious or offensive trade, business, or manufacture."

It has been generally held that these words imply that "other noxious or offensive trades, etc.," must be of the same nature as those enumerated. But by Section 51 of the P.H. (A.) Act, 1907, for the above words shall be substituted "any other trade, business, or manufacture which the local authority declare by order confirmed by the Local Government Board, and in such manner as the Board direct, to be an offensive trade." By this action the local authority may make by-laws with respect to any trade which is an offensive trade under Section 112 as amended. If the Ministry of Health sees fit therefore to include trades, etc., not of the same nature as those included in Section 112, this distinction *pro tanto* breaks down. It would appear, however, that these conditions must be observed: any new trades, etc., included must be or have been actively a nuisance in the district, the need for their inclusion must be clearly demonstrated, and they must not be such as can be dealt with under the Alkali Acts. By-laws may be framed for any one of the trades, etc., under Section 112 enlarged by the above means. It is illegal to establish any such trade within an urban sanitary district without the consent in writing of the local authority. Section 19 of the Public Health (London) Act, 1891, makes it illegal (*a*) to establish anew "the business of a blood boiler, bone boiler, manure manufacturer, soap boiler, tallow melter, or knacker"; and (*b*) to establish anew, without the sanction of the county council, "the business of fellmonger, tripe boiler, slaughterer of cattle or horses, or any other business which the county council may declare by order, confirmed by the Local Government Board, and published in the *London Gazette*, to be an offensive business." The subject of offensive businesses has already been referred to (p. 56). Section 113 of the Act of 1875 empowers sanitary authorities to make by-laws with respect to offensive trades, and Section 19 of the London Act confers a like power on the London County Council.

Section 114 of the Act of 1875 (and the corresponding section [21] of the London Act) give power to local authorities to deal with any of the following premises, from which effluvia are evolved, which are certified by the medical officer of health, or two legally qualified medical practitioners, or ten inhabitants of a district, to be a nuisance or injurious to health. The premises referred to are: "Any candle house, melting house, melting place, or soap house, or any slaughter house, or any building or place for boiling offal or blood, or for boiling, burning, or crushing bones, or any manufactory, building, or place used for any trade, business, process or manufacture, causing effluvia." On such certification being made, it is the duty of the local authority to take proceedings, and the offender is liable to a penalty not exceeding £5, unless he can show that he has used the best practicable means for abating the nuisance, or preventing or counteracting the effluvia. (In London the fine must not exceed £50.) Section 115 of the Act of 1875 (Section 21 of the London Act) gives power to authorities to take action in cases in which nuisance is caused in their districts by offensive trades carried on in premises situated beyond the limits of the district.

Before any legal proceedings are taken, the official must assure himself that all practicable means have not been adopted to prevent the occurrence of nuisance.

In advising proceedings, the medical officer of health could probably consider whether the effluvium nuisance is *ejusdem generis* with those mentioned under Section 112 (either as it stands or as enlarged by order of the Ministry), such as gluemaking, gutscraping, manure making, fish frying, etc., and to take other effluvium nuisances, such, for example, as those arising from the manufacture of tarpaulins, making of firelighters, etc., under Section 91. Proceedings in regard to effluvium nuisances coming under the Alkali Acts should not be taken without previous consultation with the alkali inspector.

Unsound Meat, etc.—Section 116 provides that—"Any medical officer of health, or inspector of nuisances, may at all reasonable times inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour or milk exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and intended for the food of man, the proof that the same was not exposed or deposited for any such purpose, or was not intended for the food of man, resting with the party charged; and if any such animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, appears to such medical officer or inspector to be diseased, or unsound, or unwholesome, or unfit for the food of man, he may seize and carry away the same himself or by an assistant, in order to have the same dealt with by a justice."

Among the articles specified above, eggs, butter, and cheese are not included; further, no proceedings can be taken if the articles have been already sold. The Public Health Acts Amendment Act, 1890, extends the power to take proceedings to all articles intended for the food of man sold or exposed for sale; it also provides for the condemnation of any article by a justice without previous seizure.

Section 118 of the Act of 1875 imposes a penalty for obstruction, and Section 117 provides for condemnation by a justice, and destruction of any article seized, and for the imposition of a penalty not exceeding £20, or of imprisonment for a term of not more than three months. Section 15 of the Markets and Fairs Clauses Act, 1847, which is incorporated with the Act of 1875, deals with the sale of unwholesome meat or provisions in a market or fair regulated by the local authority; Section 42 contains provision for making by-laws for preventing the sale of unwholesome provisions in a market or fair.

The Public Health (Regulations as to Food) Act, 1907, extends the powers of the Local Government Board to make regulations under the P.H.A., 1875, to the making of regulations authorising measures to be taken for the prevention of danger arising to public health from the importation, preparation, storage, and distribution of articles of food or drink (other than drugs or water). Under these powers were made:—

(1) The Public Health (Foreign Meat) Regulations, 1908, which classify the different kinds of consignment of such meat, and give directions for dealing with them in different contingencies.

(2) The Public Health (First Series: Unsound Food) Regulations, 1908, which provide for the examination of articles of food arriving by ship, and for the procedure incident to their investigation before and after landing, for seizure and condemnation, and for the records to be kept. Explanatory circulars have been issued.

(3) The Public Health (Milk and Cream) Regulations, 1912 and 1917. These forbade the use of preservatives in milk, and permit only boric acid and hydrogen peroxide to be used in preserved cream. No thickening substance may be used. The amount of boric acid must be specified on the label as not exceeding 0·4 per cent. Samples may be taken as under the Sale of Food and Drugs Acts. Proceedings are not to be instituted without giving the person contravening the regulations an opportunity to explain. The label attached to receptacles containing preserved cream must bear the words "not suitable for infants or invalids." The annual report of the medical officer of health must state the action taken under these regulations.

(4) The Public Health (Shellfish) Regulations, 1915, embody an effort to trace the occurrence of infection to particular layings of

shellfish, and empower local authorities to call on persons interested in particular layings to show cause why the sale of shellfish should not be prohibited until they have been relaid for a stated period. Although the remedy prescribed is, unquestionably, the right one, it is somewhat doubtful whether the regulations will arrive at it unless the residents of the locality at which the layings are situated are themselves deeply interested. A more direct procedure would appear to be to enforce the relaying of shellfish, exposed to contamination, in pure water for a fortnight.

The Public Health (Condensed Milk) Regulations, 1923, prescribe the labelling and composition of condensed milk. The label must state the equivalent amount of milk or skimmed milk contained in the tin.

Full cream milk, both sweetened and unsweetened, must contain not less than 9 per cent. of milk fat and 31 per cent. of all milk solids, including fat; skimmed milk, unsweetened, 20 per cent. of all milk solids, including fat, and sweetened milk 26 per cent.

The Public Health (Dried Milk) Regulations, 1923, similarly prescribe the labelling and composition of dried milk. The label must state the equivalent amount of full cream milk, three-quarter, half or quarter cream milk, or skimmed milk respectively of the dried full cream, partly skimmed, or machine skimmed milk powder sold.

Dried full cream milk must contain not less than 26 per cent. of milk fat, three-quarter cream milk not less than 20 per cent., half cream not less than 14 per cent., and quarter cream not less than 8 per cent.

Both regulations require that machine skimmed, condensed, and dried milk shall be labelled "Unfit for babies."

The Ministry of Health have not yet issued regulations for the storage and distribution of all or any articles of food, other than under the above heads. Yet their experience during the War would amply show the need for such regulations. Meanwhile the preparation of potted meats, sausages, etc., can be controlled under Section 91, P.H.A., 1875, with the aid of well-investigated outbreaks of food poisoning, and of the structural and other alterations thereby shown to be necessary.[1]

The need for regulating the use of horseflesh as human food became apparent when it was found not only that horseflesh was occasionally sold as ordinary butcher's meat, but also that there was reason to believe it was sometimes used for making potted meat, sausages, etc., under conditions in which the origin of the material could not be recognised by the consumer. *The Sale of Horseflesh, etc., Regulation Act,* 1889, prohibits "the sale of horseflesh for human food elsewhere than in a shop, stall, or place, over or upon which there shall be at all times painted, posted, or placed in legible characters, of not less than four inches in length, and in a conspicuous position, and so as to be visible throughout the whole time, whether by night or day, during which such horseflesh is being offered or exposed for sale, words indicating that horseflesh is sold there." Section 2 prohibits the sale of horseflesh for human food to any person who has asked to be supplied with some meat other than horseflesh, or with some compound article of food other than horseflesh.

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[1] Regulations have been drawn up under the 1907 Act which deal with the use of chemical preservatives in food; their use generally is prohibited; exceptions are made in the case of certain preservatives which may be used in certain articles of food. The colouring matters permitted to be used are mentioned. These Regulations have not been confirmed yet.

Infectious Diseases—Sections 120 to 130 relate to disinfection, etc., and they are supplemented and amended in certain important particulars by the Infectious Diseases (Prevention) Act, 1890. Section 120 makes it the duty of the local authority to cause premises to be cleansed and disinfected. The procedure detailed is cumbersome, and Section 5 of the Infectious Diseases (Prevention) Act of 1890 substitutes other provisions which are more effectual. On a certificate of the medical officer of health, or other registered practitioner, the clerk to the authority gives written notice that the premises will be cleansed and disinfected by the authority, at the cost of the occupier or owner, unless the said occupier or owner, within twenty-four hours, replies stating that he will do the work himself to the satisfaction of the medical officer of health. Where the owner or occupier is unable to effectually cleanse or disinfect the house, this may be done without notice by the officers, and at the cost, of the local authority. Penalties are provided in cases of exposure of infected persons and things, for failing to disinfect public conveyances, for letting houses in which infected persons have been lodging, and in the event of persons making false statements (in connection with such letting) as to infectious disease. Moreover, persons, who cease to occupy houses in which there has been infectious disease within a period of six weeks, without previous disinfection or first giving notice to the owner, or who make false answers, with regard to the matter, are also liable to penalty.

The local authority may destroy infected bedding, etc., and give compensation; they may provide a disinfecting apparatus [1] and disinfect free of charge; they may provide an ambulance, and, in cases where a person is suffering from any dangerous infectious disease, and is without proper lodging or accommodation, or lodged in a room with more than one family, or is on board any ship or vessel, a justice may make an order (on the certificate of a medical practitioner) for the compulsory removal of such person to a hospital within a convenient distance. A person lodged in a common lodging-house may be similarly removed at the instance of the local authority.

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[1] In London the provision of "proper premises with all necessary attendance for the destruction and for the disinfection, and carriages or vessels for the removal," of infected articles is made obligatory upon the sanitary authority. The authority must, moreover, provide temporary shelter or house accommodation for persons compelled to leave their dwellings while the process of disinfection is in progress. Such provision is only required, outside London, in places where the Infectious Diseases (Prevention) Act, 1890, is in force.

Section 130 empowers the Local Government Board to make regulations, as to the treatment of persons affected with cholera or any other epidemic, endemic, or infectious disease and for preventing the spread of the same, and to declare by what authority or authorities such regulations may be enforced. Section 134 empowers the Board to make regulations whenever any part of England appears to be threatened with, or is affected by, any formidable epidemic, endemic, or infectious disease for the following purposes:—

(1) For the speedy interment of the dead.

(2) For house-to-house visitation.

(3) For the provision of medical aid and accommodation; for the promotion of cleansing, ventilation, and disinfection; and for guarding against the spread of disease.

PORT SANITARY WORK

The Public Health Act, 1896, repealed the old Quarantine Act of 1825, and extended the powers of the Local Government Board as regards making Orders under Sections 130 and 134. Moreover, the *Public Health Ports Act*, 1896, authorised the Local Government Board to apply the Infectious Diseases (Prevention) Act, 1890, to any port sanitary district.

The earlier Orders issued by the Board contained provisions to be exercised by the officers of Customs (with the consent of the Commissioners of Customs),[1] as well as by the officers of port sanitary authorities. On the repeal of the old Quarantine Act the Board issued in 1896 the Order now in force, which contains *Regulations as to Cholera, Yellow Fever, and Plague*, of which the following summary may be given:—

Every port sanitary authority must provide a place for mooring, at which persons can be landed from ships "coming foreign" which are infected, and must provide for the reception of actual or suspected cases of cholera, yellow fever, plague, small-pox, or other dangerous infectious disease. An "infected" ship is one on which there has been, while in the port of departure or on the voyage, a case of one of the above-named diseases, and any such ship must fly a black and yellow flag when within three miles of the coast of England or Wales. The Customs officer must ascertain whether each ship arriving is infected, and if there is reason to believe it is, or if it has come from an infected port, he must obtain a written statement from the surgeon, if there be one, or from the master of the vessel. If he finds the ship infected he must order it to be anchored, and give notice to the port authority.

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[1] Before the Public Health Act, 1896, came into force the Privy Council, aided by officials of the Board of Trade, was the Quarantine Authority.

The medical officer of health must visit any ship concerning which he receives information, and may visit any ship from an infected port. If he finds the ship infected he must cause it to moor in the appointed place, and examine every person on board. Persons suffering from one of the diseases named must be removed to hospital, and suspects may be detained either on the ship, or in some place provided by the authority, for not more than two days. Other persons are permitted to land on satisfying the medical officer of health as to their place of destination, and their names and addresses are transmitted to the sanitary authority of the district in which such destination is situate.

The medical officer of health must give directions as to any steps necessary for preventing the spread of infection, as to the disinfection or destruction of clothes, etc., and he may order bilge water to be pumped out before the ship enters dock, and may cause water-ballast tanks to be pumped out or sealed, and tanks containing drinking water to be emptied and cleansed. If the ship is suspected to be infected with plague the master, if so desired by the medical officer of health, must take effectual measures for the destruction of rats.

In the event of a fatal case occurring on board, the master must bury the body at sea or deliver it to the port authorities for interment. If a vessel, though not infected, has passengers on board who are in a filthy or otherwise unwholesome condition, such persons shall not be allowed to land until they have satisfied the medical officer of health as to their place of destination. The sanitary authority of the place in which such place of destination is situate is then communicated with, as aforesaid.

Orders have been from time to time issued by the Local Government Board prohibiting the importation of rags from infected ports. In 1900 an Order was made declaring plague a notifiable disease; again, in 1901, an Order was issued providing for the destruction of rats, in connection with vessels coming from ports infected with plague. In 1893, when there was a threatened prevalence of cholera, epidemic regulations were made under Section 134 by the Board. Two Orders—the Grimsby and Cleethorpes Orders of September 1 and 6, 1893—were issued; they provided, *inter alia*, for daily meetings of the local authorities or their committees, the appointment of medical visitors, etc., the opening of dispensaries, the speedy interment of the dead, and the furnishing of daily returns to the Local Government Board.

Quarantine has been gradually transformed from its old cumbersome, hampering and ineffective shapes to the comparatively effectual and simple procedures now adopted, based partly on a better knowledge of the diseases to be guarded against, and partly on experience of what is practicable and effective. For detention and quarantine are now substituted rapid measures of inspection, isolation of cases of disease and, possibly, of contacts, and disinfection. The coast-line is divided amongst port sanitary authorities and riparian authorities who are also local authorities deal with the banks of rivers. It is also divided into Customs ports, and a Customs port may contain one or more sanitary districts. Every Customs port has two boarding stations, one for "infected" or "suspected" vessels, the other "for all other vessels," by which is meant the place where the vessel is bound for discharge of cargo and passengers, and for boarding. In practice, "infected" and "suspected" vessels bring to at the Customs boarding station. The medical officer of health may inform the Customs officer that he wishes to inspect vessels coming from ports or places where infectious diseases are prevalent, in which case that officer detains the vessel for his inspection. "The port sanitary authorities exercise over the waters of the port and over the shipping therein the same functions as sanitary authorities exercise on land with certain additional duties; and, for the purpose of carrying them out, all port sanitary authorities must appoint a medical officer of health and a sanitary inspector, and, if necessary, assistant sanitary inspectors, some of whom must have special qualifications as food inspectors, and they must provide isolation hospital accommodation for cholera, plague, small-pox, and other infectious diseases, either directly or by arrangement with other local authorities."

The diseases requiring to be guarded against at present are cholera, plague, typhus fever, and small-pox. Cholera does not present great risk, unless it should reach the coasts bordering on the North Sea. Plague is little likely to be introduced by human agency, but infected rats are a serious danger. The destruction of rats on board ship is a troublesome problem. Sulphurous acid damages machinery and spoils oil paint. Recently hydrocyanic acid has been employed with effect, but is dangerous. A disinfectant, "cyclon," which is a mixture of methyl cyano-formate and methyl chloro-formate, has been employed in Holland, and promises to give good results. Precautions have also to be taken to prevent rats from landing. It is the practice of the port sanitary or riparian authority, when contacts are liberated from an "infected" or "suspected" vessel to communicate their names and addresses to the local authority to whose area they state themselves to be bound. It is not infrequently found that they cannot be subsequently discovered, and no machinery has yet been devised to secure that an opportunity will be given for supervising their movements.

Convenience for examination of passengers is a desideratum. There is also a lack of isolation accommodation on board ship. Port sanitary authorities feel the lack of control of shore nuisances and of conveniences at landing stations.

The duties of port sanitary authorities are partly national and partly local, and in 1920 the Government made a grant in aid of 50 per cent. of their expenses. In the same year the Port Sanitary Authorities (Infectious Diseases) Regulations, 1920, were issued, which confer increased powers and impose new duties on port medical officers of health. The more important of the provisions are—

Clause 4. The medical officer of health may, and if so required by the sanitary authority or the Minister, shall—

(*a*) Examine any person who is suffering from infectious disease on board a ship.

(*b*) Examine any person who is on board a ship, where he has reasonable grounds for believing or suspecting that infectious disease is or may be present on the ship, or that persons on board the ship have been exposed to infection from infectious disease during the voyage, or during a period of three weeks immediately preceding the arrival of the ship in the district.

(*c*) Examine any person on board a ship who is reasonably believed to be verminous.

(*d*) Detain for the purpose of examination either upon the ship or at some appointed place on shore any person whom he is empowered or required under this Article to examine.

(*e*) Cause any such person and the clothing of, or any other articles belonging to, such person to be cleansed and disinfected.

(*f*) Prohibit any such person from leaving the ship, or only on conditions specified in writing by the M.O.H. which appear to him reasonably necessary. . . .

(*g*) Require the master to take or assist in taking such steps, as, in the opinion of the M.O.H., are necessary to prevent the spread of infection by such person, and for the removal of conditions on the ship likely to convey infection. . . .

6. The master of the ship shall . . . notify forthwith to the M.O.H. any case of infectious disease on the ship, any circumstances on board likely to lead to infection, including the sanitary condition of the ship, and the presence of dead rats or mortality or sickness among rats in the ship . . . and comply with any directions or requirements of the sanitary authority or the M.O.H.

8 (*c*). The sanitary authority may provide or arrange for the provision of—

i. Premises and waiting-rooms for the purposes of medical examination.
ii. Apparatus or means for the cleansing and disinfection of ships, persons, clothing, and other articles.
iii. Premises for the temporary accommodation of persons for whom such accommodation is required for the purposes of these regulations.

9. Gives power to the port sanitary authority to require the cleansing of the whole ship.

The port medical officer also may act as examining medical officer under the Aliens Order of 1920, when clause 4 (*b*) above is likely to be useful.

The duties of a port sanitary medical officer of health are defined by the Order of 1910. By this Order he is to inform himself respecting conditions affecting or threatening to affect the health of the crew, to investigate the causes and origin of diseases in the ships, etc., within the port and to endeavour to remove them. When informed of the presence of infectious disease on board ship, he must visit and investigate, and take such steps as are in his power to prevent extension. He must forthwith report to the Ministry of Health and the county council concerned any case of cholera, plague, or small-pox, or any serious outbreak of infectious disease. On information given by the inspector of nuisances of overcrowding, he is forthwith to take such steps under the Public Health Act, 1875, as the circumstances may justify. When there has been infectious disease on board, he must inform the M.O.H. of any port in the United Kingdom for which the vessel is about to sail. There is apparently no statutory obligation to send information to other M.O.H.'s than as above. Under the Public Health (Regulations as to Food) Act, 1907, the Ministry of Health issued two sets of regulations, *viz.*, the Public Health (Foreign Meat) Regulations, 1908, and the Public Health (First Series : Unsound Food) Regulations, 1908. These fell to the medical officer of health to administer and the Foreign Meat Regulations especially required the exercise of considerable acumen. The object was the exclusion of unsound consignments of scraps, meat treated with preservatives, and meat from which traces of disease had been removed. In these objects, the administration appears to have been successful. The second set of regulations dealt with other forms of food. The exclusion of unsound food may constitute a large part of the duties of a port medical officer.

Port sanitary authorities and riparian authorities also have to administer the Shellfish Regulations, 1915, made under the same Act.

Measures against trachoma fall chiefly to the lot of the Medical Examiner of Aliens.

1. Aliens who are entering the country for more than three months' residence are submitted to full medical examination. If any such person is found to be suffering from trachoma, a medical certificate is given to the Immigration Authority, recommending that the subject be refused permission to land, and the person then returns by the next boat to the port of embarkation.

2. Aliens coming for a shorter period than three months are only subjected to a rapid survey as they pass the Medical Officer on landing. If any of these persons are found to have any doubtful condition of the eyes, they are brought in for full medical examination, and, if found to be suffering from trachoma, a note is made of their name and destination, and the fact that they are suffering from the disease is notified to the M.O.H. of the district to which they are proceeding.

3. Alien transmigrants, passing through this country under bond, by arrangement between the Home Office and the Shipping Companies, are examined specially as to trachoma. If they are suffering from the disease, the Medical Officer of Health of the Port from which they intend to leave this country is notified, as well as the Shipping Company and the Ministry of Health. These persons are ultimately returned to their country of origin, under agreement with the Shipping Companies.

Prohibition of the Supply of Infected Milk—In places in which the Infectious Diseases (Prevention) Act, 1890, is in force powers for this purpose can be exercised. Section 4 of the Act provides that where the medical officer of health has reason for believing that infectious disease in his district is attributable to milk from any dairy, whether within or without the district, he may, if authorised by a justice having jurisdiction in the place where the dairy is situate, inspect the dairy, and, if accompanied by a veterinary surgeon, the animals therein. If on such inspection he concludes that the infectious disease is caused by the milk he must report to his authority, who may then summon the dairyman to appear to show cause why the supply of milk in their district should not be prohibited. If he fail to show such cause the authority may order accordingly, and non-compliance then renders the dairyman liable to a penalty not exceeding £5, and if the offence is repeated to a further penalty not exceeding forty shillings a day so long as the offence continues.

The London Act contains provisions similar to these, and somewhat more comprehensive powers are given in the Scotch Act. The procedure detailed above will be seen to entail much delay, and the penalty for non-compliance with an order, if made, is a small one; moreover, there is no requirement that a milk vendor shall furnish information with regard to his sources of supply, or that he shall provide the medical officer of health with lists of his customers. The section much needs amendment. In practice the dairyman, in order to safeguard his own interests, is usually prepared to stop the supply of infected milk, without waiting for the above-mentioned formalities to be complied with. In the event, however, of the dairyman not being willing to take action on the advice of the medical officer of health, an infected supply can, in the existing state of the law, be distributed with impunity for a number of days, pending the necessary technicalities detailed above being observed, with a view to the order being issued.

The position of legislation as regards information in the presence of an outbreak is somewhat anomalous. Whereas under Section 41 of the Public Health (Scotland) Act, 1897, a local authority may require from a dairyman within a fixed time, a complete list of customers, but not the source of supply, under the Public Health Acts (Amendment) Act, 1907, if adopted, an English authority may require under Section 53, a complete list of the sources of supply, but cannot thus obtain a list of customers. Both kinds of information are required ; the list of customers saves time in investigating an outbreak.

Cleansing of Persons Act, 1897—This Act may be mentioned here, although it does not relate to the infectious diseases which have been the subject of consideration in the preceding paragraphs, but deals with the question of destruction of vermin. The Act empowers a local authority to expend money in providing buildings, appliances, and attendants with the object of cleansing the bodies, and disinfecting the clothing, of verminous persons who may make application to have this service performed. It was urged when the Bill was before Parliament that little use would be likely to be made of the facilities afforded, inasmuch as those in need of cleansing would be unwilling to acknowledge that they were verminous persons, but, as a matter of fact, the appliances provided have been extensively used, and great benefit has resulted from the exercise of the powers conferred on the authority. All the same, a verminous condition of the person should be made notifiable, and cleansing compulsory.

Baths and Washhouses—The Act of 1846 first facilitated the provision of public baths and washhouses, subject to the approval of the Secretary of State. In 1871 the Local Government Board was made the approving authority in regard to such matters. Section 10 of the Act of 1875 enables urban authorities to act, under the various statutes, to the exclusion of other authorities. In rural areas the adoption of the Baths and Washhouses Acts may only be exercised by the Parish Meeting (Local Government Act, 1904). The London Government Act, 1898, places the control of baths and washhouses in the hands of borough councils.

Hospitals—Sections 131 to 133 of the Act of 1875 relate to hospital provision. Any local authority may build, or contract for the use of hospitals, and authorities may combine for the purpose ; further, the expenses of maintenance may be recovered from a patient who is not a pauper.

The Isolation Hospitals Acts, 1893 *and* 1901—The object of the

Act of 1893, Lord Thring's Act, was the promotion of the establishment of isolation hospitals. It does not apply to London, to county boroughs, to any borough with a population of 10,000 without the consent of the borough council, or to any borough with a smaller population without the like consent, or unless the Local Government Board direct that the Act shall apply to such borough. Certain limited powers are given by the Act to county councils enabling them to provide hospitals, or to cause them to be provided. The county council may cause local inquiries to be held for the purpose of constituting "hospital districts," comprising one or more local areas. If any local authority object to being included in a hospital district there is a right of appeal to the Local Government Board. For the management of the hospital a committee is constituted by the county council, and if the cost of the hospital is in part paid from the county fund the committee may consist wholly, or in part, of county councillors. Otherwise it will be composed entirely of local representatives. The committee may undertake the training of nurses, and may charge for their attendance outside the hospital. An ambulance or ambulances must be provided, and, if practicable, the hospital must be "in connection with the system of telegraphs." The amending Act of 1901 removed certain difficulties experienced by hospital committees under the original Act.

Mortuaries—Sections 141 to 143 of the Act of 1875 relate to mortuaries. The local authority may, and, if required by the Local Government Board, must, provide a mortuary, and may make bylaws for its management. Section 142 provides that where the dead body of one who has died of any infectious disease is retained in a room in which persons live or sleep, or where any dead body which is in such a state as to endanger the health of the inmates of the same house or room, is retained in such house or room, any justice may, on a certificate signed by a legally qualified medical practitioner, order the body to be removed at the cost of the local authority to any mortuary provided by such authority, and direct the same to be buried within a time to be limited by such order. If the friends fail to bury the body the relieving officer must do so at the expense of the poor rate, and he may recover the cost from any person legally liable to pay the expense. Section 143 empowers a local authority to provide a place for post-mortem examinations, otherwise than at a workhouse or at a mortuary. In places in which the Infectious Diseases (Prevention) Act, 1890, is in force it is further provided that the body of a person who has died of any infectious disease shall not, without a certificate from the medical officer of health, or a registered medical practitioner, be retained for more than forty-eight hours, save in a mortuary or in a room which is not being used at the time as a dwelling-place, sleeping-place, or workroom. If the death has occurred in a hospital, on a certificate from the medical officer of health or other registered medical practitioner, the body must be removed direct to a cemetery, or to a public mortuary. Further, no such body must be conveyed in any public conveyance (other than a hearse) without due warning being given to the owner, or driver, who must forthwith provide for disinfection.

Early burial is very desirable; although the onset of putrefaction is influenced by the cause of death and the condition of ventilation of the room in which the dead body is kept, with an atmospheric temperature of 60° F. offensive smells are given off about the 4th day. Undertakers should wear rubber gloves and cover their arms when handling corpses dying from infectious disease—anthrax and small-pox present especial dangers. Fluid derived from corpses accumulating in the coffin can be overcome by the use of zinc-lined and properly pitched coffins,[1] lesser degrees by filling the coffin with sawdust. In deaths from infectious disease the body should be wrapped in a sheet saturated with a strong disinfectant, and if necessary the apertures of the body plugged with wool soaked in the same solution.

The "sanitary provisions" of the Act of 1875 are for the most part contained in Part III. of that Act: the sections relating to default of local authorities will be found in Part IX., which has concern with the functions of the Local Government Board: Part VIII. of the Act contains provisions as to combination of sanitary authorities for the appointment of a medical officer of health, and as to the union of districts for certain sanitary purposes; there are also sections dealing with port authorities.

Part IV. contains a number of "local government provisions" of sanitary importance. These, in so far as they relate to new streets and buildings, have been already referred to. Certain sections of the Towns Improvements Clauses Act, incorporated in Section 160 of the Act of 1875, give the surveyor of an urban authority powers of control over dangerous structures.

Slaughter-houses, etc., are referred to in Sections 166 to 170 of Part IV. Section 166 empowers an urban authority to provide markets, and Section 169 enables such an authority to construct abattoirs or slaughter-houses, and if they do so they must make by-laws with respect to management and charges. They may, moreover, *license* slaughter-houses and knackers' yards not used at the time of the passing of the Act, and they must *register* all establishments of the kind in question. The owner or occupier of any slaughter-house must exhibit a notice in a conspicuous part of his premises indicating that the place is used as a "licensed slaughter-house or registered slaughter-house," as the case may be. Licences, it should be observed, are not, under this Act, annually renewable, but are granted once for all. The duty of making by-laws with respect to slaughter-houses and knackers' yards is imposed on all urban authorities. Any person convicted of killing or dressing any cattle contrary to the provisions of the Public Health Act, or convicted under any by-law, is liable to have his licence suspended, by the court convicting him, for two months or less, and in the case of a second offence the licence may be entirely revoked.

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[1] See "Public Health and Disposal of the Dead," D. Forbes, "Medical Officer," Sept. 1, 1917, pp. 69 and 66.

In places where the Public Health Acts Amendment Act, 1890, is in force it is further provided that licences granted after the adoption of that Act shall remain in force only for such period, not being less than a year, as the authority shall specify; moreover, change of occupancy of a licensed slaughter-house must be notified; and, further, a court may revoke the licence of any occupier of a licensed slaughter-house who is convicted of any offence under Sections 116 to 119 of the Act of 1875, which relate to unsound meat.

Parks, Open Spaces, and Commons—Section 164 of the Act of 1875 empowers urban authorities to provide, and to make by-laws regulating, public parks and pleasure grounds. Under the Amendment Act of 1890 their powers in regard to this matter are further extended. Section 8 of the Local Government Act, 1894, confers the powers given under Section 164, with regard to village greens, etc., on parish councils. The Open Spaces Act, 1887, enables authorities, with the consent of the Local Government Board, to acquire, maintain, and regulate open spaces, including disused burial grounds. In London the Metropolitan Open Spaces Acts of 1877, 1881, and 1887 confer special powers on the London County Council, the City Corporation, and local authorities.

The Open Spaces Act, 1906, consolidates the powers of local authorities (county councils, the London County Council, urban districts, and parish councils) and enables them to transfer from or to the authority, with or without condition, from or to trustees or private persons, open spaces as pleasure grounds or for recreation. By-laws must be made for the regulation of their use. The Commons Act, 1876, Section 8, confers on urban authorities powers for the conservation of commons, as does the Metropolitan Commons Act, 1876, on the London County Council. No provision is more valuable than that of open spaces, provided that arrangements are made whereby at least a considerable amount of the open space is suitable and available for games both for young and old, provided also that they are readily accessible. Smaller open spaces with free access to sunlight should be made available and convenient for mothers with their infants.

Notification of Infectious Disease—The steady growth of appreciation of the value of the results obtained by the system of notification of infectious diseases has been a remarkable feature in the history of the development of preventive medicine during the last twenty years. Information concerning the occurrence of such disease first became available in connection with the administration of the poor law, as has been already noted; after a time, such illness if developed in common lodging-houses, canal boats, registered tenement houses, etc., was made notifiable to the local authority. Certain enterprising towns, by obtaining special powers under local Acts, made it evident that it was practicable to extend notification requirements to the general population, and at length the *Infectious Disease (Notification) Act*, 1889, was passed. This Act was, as a tentative step, made an "adoptive Act" (notification was, however, made compulsory in London). The operation of the Act of 1889 was gradually extended during "the nineties" in various parts of the country in which local Acts were not already in force, and at length, in 1899, notification was brought into operation throughout the whole of England and Wales.

The Act of 1889 scheduled certain diseases—small-pox, cholera, diphtheria, and membranous croup, erysipelas, scarlet fever, typhus fever, enteric fever, continued fever, relapsing fever, and puerperal fever—the local authority, with the consent of the Local Government Board, being empowered to add to the number of notifiable diseases. The duty of notifying was imposed on "every medical practitioner attending on, or called in to visit, the patient," the notification was to be made to the medical officer of health of the district, and a fee of half-a-crown was to be paid for each certificate relating to a private patient, and a fee of one shilling for cases attended in the course of public practice. A similar duty was imposed on the head of the family, or in his default on the nearest relatives of the patient present, or in their default on any person in charge of or in attendance on the patient, and in default of such person on the occupier of the building. Under this "dual system" it was thought to make sure of receiving notification from one or the other source; only the medical practitioner, however, was to receive a fee. In practice it has been found unnecessary to insist upon notification being made by the head of the family or the other persons placed under the obligation of notifying in his default.

At first it was supposed that difficulties might arise in connection with notification as between medical men and their patients, that the employment of unqualified practitioners would be encouraged, that the fear of publicity would lead to concealment of cases, and so on. In the early years of notification strange attempts were made to discredit its usefulness; it was even contended that where notification was adopted there was actual increase in the general death-rate or in the death-rate from notifiable diseases. Despite these contentions, notification made steady progress. It appears (Twenty-eighth Annual Report of the Local Government Board for 1898–

99) that, taking into account the adoption by local authorities of the Infectious Diseases (Notification) Act, 1889, the provisions having the same effect in several local Acts, and the provisions of the Public Health (London) Act, 1891, the system of compulsory notification of cases of infectious disease had on March 31, 1899, been applied in districts having an aggregate population of 28,118,619, out of a total population in England and Wales (1891) of 29,002,525. In addition the Act was also in force in forty-one port sanitary districts, the population of which could not be stated.

The Infectious Diseases (Notification) Extension Act, 1899, came into force on January 1, 1900, and from that date the system of notification became operative in every urban, rural, and port sanitary district in England and Wales. From the annual report of the Local Government Board for 1898–99 it appears that at that time 132 authorities had from time to time availed themselves of the power given them to require the notification of diseases other than those specified in the Act. In 110 cases the Act had been extended to measles; in 7 to rubella or German measles; in 26 to whooping-cough; in 8 to chicken-pox; and in 1 each to mumps, hydrophobia, yellow fever, and plague.[1] But in 38 of the above cases the addition of measles had subsequently been revoked; in 7 the addition of whooping-cough, in 4 the addition of chicken-pox, and in one the addition of hydrophobia had also been revoked. In one case, moreover, the Act had been only extended to measles for a limited period, which period had expired.

It may be noted that in London the county council as well as the local authorities is empowered to extend compulsory notification to diseases other than those scheduled, and if such extension is made by the county council, the disease added becomes, of course, notifiable throughout the county; chicken-pox was thus made notifiable in London during 1902. Further, in London the notification certificate differing from that originally used for the country generally, required the age and sex of the patient to be specified. In London "dangerous infectious diseases" are defined as including only those which are compulsorily notifiable, and any other infectious disease to which the sanitary authority may order the prevention clauses of the Public Health (London) Act, to be applied; hence penalties for failure to take precautions against spread of infection, etc., do not apply to diseases other than these diseases.

The inclusion of erysipelas among notifiable diseases has been the subject of much criticism; the relationship of this disease to puerperal fever, however, makes it specially desirable that careful record should be kept of its occurrence; moreover, the possibility that erysipelas may occur in connection with vaccination has been urged as a reason for making erysipelas notifiable. Puerperal fever notifications specially need to be carefully inquired into. The high case-mortality of puerperal fever, as deduced from applying deaths from, to notifications of, the disease, suggests that only some of the cases of puerperal fever are notified.

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[1] On September 19, 1900, the Local Government Board made epidemic regulations declaring plague an infectious disease, notifiable under the Act throughout England and Wales.

There has been much controversy as to the desirability of extending the notification requirements to other diseases, particularly to measles and phthisis. With regard to measles it has been pointed out, on the one hand, that in many instances medical men are not called in to attend at any stage of the illness, and that therefore there is likely to be special difficulty in securing notification of a considerable number of cases; further, that measles is specially infectious early in the course of the disease and before the rash appears, and thus, ere the malady has yet declared itself, and before therefore preventive measures can be thought of, much mischief has been done; again, to isolate measles in a comprehensive way would require extensive hospital provision, and, as most of the sufferers are young infants, there might be difficulty in securing their removal to hospital; further, the cost of a system of measles notification has been held by some to be altogether prohibitive. On the other hand, the fact that the mortality from measles remains high, while that from certain other diseases specially affecting children has been materially reduced within recent years, has been urged as a reason for making the attempt to control the spread of the malady. It has been pointed out that small-pox, like measles, is infectious in its early stages; that small-pox was once especially prevalent among young children, and that preventive measures have been found particularly useful as a means of controlling the spread of the malady. Moreover, as Newsholme remarks, the difficulty as regards the early infectivity of measles "is not a sufficient reason for refraining from an attempt to control the disease during its subsequent course, during which it probably still remains infectious, though to a less extent."

As a matter of experience, the notification of measles, if only in first cases in the house, when adequately followed up by a competent staff, is found to produce a decided impression at all events on mortality, when conjoined with restriction on the attendance of individual cases at elementary schools.

Newsholme estimated the cost of notification at some £50,000 per annum, on an average, for the whole country, but, as he says, this is on the assumption "that the present machinery of notification is incapable of modification," whereas nothing would be easier than to arrange, for example, that only the first notification in each house should be paid for. In addition to notification fees, the increased work entailed in connection with utilisation of the knowledge gained would, however, have also to be considered. The explosive character of measles outbreaks tends, of course, to throw the additional work upon the staff of a sanitary authority all at one time.

The question of the control of measles was the subject of a report by Theodore Thomson, which appears in the Twenty-fourth Annual Report of the Medical Officer of the Local Government Board. The measures which it is practicable to adopt were considered in this report under the following heads :—(1) Sources whence information may be derived by sanitary authorities as regards occurrences of measles in their districts ; (2) measures whereby extension of measles within the invaded dwelling may be limited ; and (3) measures whereby extension of measles throughout the invaded district may be checked. The general conclusion arrived at is that in no single district in which inquiry had been made had all the practicable measures of precaution for the prevention of measles been systematically adopted. Sir Richard Thorne, in summarising Th. Thomson's report, observed : "Where compulsory notification of measles is utilised, by prompt and systematic visitation, as a clue to the existence of unreported cases ; where knowledge thus acquired is supplemented by information derived from school authorities and properly utilised ; where, in inter-epidemic periods or during stages before epidemics have passed beyond control, measures are adopted with a view to isolation and disinfection ; and where judicious restrictions are imposed on attendances at elementary and other schools, much more is to be looked for in the control of measles than has heretofore been attained ; but it cannot be too clearly understood that good result is not to be expected from the adoption of any one of these several measures ; and that if any approach to complete success be aimed at, each one of the several measures indicated must be regarded as necessary and supplementary to the others."

As regards the notification of phthisis, certain special difficulties have been emphasized, such as the chronic nature of the malady and the extent to which bacilli have been expectorated before the disease comes under notice, the likelihood of particular cases being again and again notified, and the probability that objection would be raised on the ground of interference with business and other relationships, this difficulty being specially likely, of course, to occur in a malady, mainly affecting adults, and which should therefore be distinguished from those notifiable diseases which usually attack children. Again, it has been said that to require notification with a view to destroying tubercle bacilli is altogether to mistake the nature of the problem to be dealt with, for the tubercle bacillus is practically omnipresent ; the fact that a large proportion of persons are immune to the bacillus should, it is urged, serve as the guide to prevention which should aim at fortifying the resistance of the patient.

After various preliminary stages the notification of tuberculosis, in all forms, was made compulsorily notifiable by the Local Government Board in 1912. Apart altogether from its utility in connection with preventive measures, it has been found necessary in connection with the schemes of treatment initiated by the National Insurance Act, 1911. The Ministry of Health have in recent years, issued regulations making obligatory the notification of other diseases, cerebrospinal fever and acute poliomyelitis in 1912, ophthalmia neonatorum in 1914, acute encephalitis lethargica and acute polioencephalitis in 1918, cases of primary pneumonia and influenzal pneumonia in 1919, and in the same year malaria, dysentery, and trench fever. The Ministry also issued regulations empowering a medical officer of health to prevent a carrier either of enteric (defined as including both typhoid and paratyphoid) or dysenteric infection from continuing any occupation connected with the preparation or handling of food or drink for human consumption.

In dealing with cases of ophthalmia neonatorum, carefully selected well-trained ophthalmic nurses should be appointed to visit homes and show mothers how to carry out the instructions of the medical attendant, conferring with him when necessary. They will also have to take active and prompt measures in certain cases for removal to an eye hospital. They will act in subordination to their official head, but not so as to lose valuable time. Apparently there is some instruction that cases of infectious disease occurring in a fever hospital are not to be notified. This is both wrong and mischievous.

The Local Government Board also instituted weekly printed returns of infectious disease from all sanitary districts. For that purpose, the medical officer of health must send in to the Ministry of Health every week a return of all cases of notifiable disease. The Ministry publish an annual summary of the facts with some additional information. These returns not merely act as a system of intelligence, but are calculated to aid research; *e.g.*, it has thus become clear that scarlet fever is subject to some general seasonal influence, like typhoid fever and epidemic diarrhœa.

The two "Adoptive Acts" of 1890 have been already referred to from time to time; their main provisions may be here conveniently summarised.

The Public Health Acts Amendment Act, 1890, Part III., deals with the discharge of injurious substances into sewers; with nuisances arising from the common use of sanitary conveniences, and with the provision of suitable conveniences with separate accommodation for each sex in workshops and factories; it empowers by-laws to be made for certain purposes (see p. 754); it prohibits new buildings being erected on polluted sites ; it provides for the cleansing of common passages ; it deals with the pollution of streams by solid refuse ; it extends the scope of Sections 116–119 of the Act of 1875 relating to unsound meat ; finally, it gives certain additional powers with regard to slaughter-houses and common lodging-houses.

The Infectious Diseases (Prevention) Act, 1890, contains important provisions relating to milk supplies ; it simplifies the procedure with regard to disinfection ; it gives additional powers for securing the prompt interment of dead bodies ; it empowers a justice to order a person suffering from any infectious disease, who is an inmate of an infectious diseases hospital, to be detained for any specified period ; it makes it the duty of a local authority to provide temporary shelter, with any necessary attendance, for persons who are compelled to leave their dwellings while disinfection is in progress ; finally, it prohibits infectious rubbish being thrown into any receptacle for refuse without previous disinfection.

The Sale of Food and Drugs Acts, 1875–1899—The principal Act, that of 1875, originally defined food as " every article used for food or drink by man, other than drugs or water." Question arose as to whether flavouring matters and articles, such, for example, as baking powder, which were used in the preparation of food, were included, and in Section 26 of the Act of 1899 the point was made clear by addition of the words " and any article which ordinarily enters into, or is used in the composition or preparation of, human food ; and shall also include flavouring matters and condiments." Drug is defined as including " medicine for internal or external use." In the case of articles such as sulphur, carbolic acid, and sulphuric acid, which have a commercial as well as a medicinal use, difficulty as to interpreting the definition might arise, and it would be for the magistrate to determine whether the particular sale in question was a sale for medicinal purposes.

Sections 3 and 4 of the Sale of Food and Drugs Act of 1875 are concerned with a particular class of offences, the adulteration of food and drugs respectively, with substances injurious to health. They provide that no person shall mix colour, stain, or powder, with any ingredient or material, any article of food, so as to render it injurious to health, or any drug so as to affect injuriously the quality or potency of the drug, or shall sell such food or drug, under a penalty not exceeding £50 for a first offence ; every offence, after a conviction for a first offence, to be a misdemeanour, for which the person on conviction shall be imprisoned for a period not exceeding six months with hard labour. Convictions under these sections are comparatively rare ; to obtain them it is necessary to prove that the adulteration is dangerous to health (or in the case of a drug that its quality or potency has been injuriously affected), and that the person charged with the adulteration has guilty knowledge of the same.

Sections 6, 7, and 9. Section 6 prohibits the sale "to the prejudice of the purchaser, of any article of food, or any drug, which is not of the nature, substance, or quality of the article demanded." Section 7 prohibits the sale of any compound article of food, or compounded drug, which is not composed of ingredients in accordance with the demand of the purchaser. Section 9 prohibits the abstraction from any article of food, of any part of it, so as to affect injuriously its quality, substance, or nature, or the sale of any article so altered without making disclosure of the alteration. In the case of these offences a smaller penalty (one not exceeding £20) is prescribed. The majority of the prosecutions under the Act are instituted under these sections, and more particularly under Section 6. For securing a conviction there is no necessity to prove guilty knowledge, as is the case in offences under Sections 3 and 4.

There are certain limitations to the operation of Section 6, which contains a proviso that no offence shall be deemed to have been committed under the section in the following cases:—

(1) Where any matter or ingredient not injurious to health has been added to the food or drug because the same is required for the production or preparation thereof, as an article of commerce, in a state fit for carriage or consumption, and not fraudulently to increase the bulk, weight, or measure of the food or drug, or conceal the inferior quality thereof.

(2) Where the drug or food is a proprietary medicine, or is the subject of a patent in force, and is supplied in the state required by the specification of the patent.

(3) Where the food or drug is compounded, as in this Act mentioned.

(4) Where the food or drug is unavoidably mixed with some extraneous matter in the process of collection or preparation.

It rests with the defendant to prove that his particular case comes within any of these exceptions (Section 24). Section 8 enables the seller to safeguard himself "in respect of the sale of an article of food or a drug mixed with any matter or ingredient not injurious to health, and not intended fraudulently to increase its bulk, weight, or measure, or to conceal its inferior quality," by supplying to the purchaser a notice, by a label, to the effect that the same is mixed. Again, Section 25 provides that the defendant shall be discharged if he prove that he bought the article "as the same in nature, substance, and quality as that demanded of him by the prosecutor, and with a written warranty to that effect, that he had no reason to believe at the time when he sold it that the article was otherwise, and that he sold it in the same state as when he purchased it."

Under Section 10 of the Act of 1875, local authorities were empowered, subject to the approval of the Local Government Board, to appoint public analysts.

Under Section 12 of the Act of 1875, a public analyst is bound, on payment of his fee, to make an analysis of any article of food or drug purchased by any person. The sample is usually obtained, however, by an official purchaser—the medical officer of health, inspector, or other officer appointed for the purpose by the local authority. In connection with the purchase, Section 14 provides that the seller or his agent must be "notified of the intention to analyse the same, and the person purchasing must offer to divide the article into three parts, to be then and there separated, and each part to be marked, and sealed, or fastened up, in such manner as its nature will permit, and shall, if required to do so, deliver one of the parts to the seller or his agent. He shall afterwards retain one of the said parts for future comparison, and submit the third part, if he deems it right to have the article analysed, to the analyst." The official purchaser may, moreover, procure at the place of delivery a sample in the course of delivery (Section 3, Act of 1879, and Section 14, Act of 1899). Again, under Section 10 of the Margarine Act of 1887 he may take, without purchase, a sample of butter. The Commissioners of Customs have power to take samples of imported articles (Section 1, Act of 1899).

The public analyst's certificate must be in a prescribed form, and is sufficient evidence of the facts therein stated, unless the other party requires the analyst to be called. The court may, if it thinks fit, and must, at the request of either party, send a sample to the Government Laboratory for further analysis. Amendments first introduced in the Act of 1879 settled some disputed points. Thus, it was to be no defence to say the purchaser was not prejudiced because he merely purchased for analysis, or to allege that the substance, though defective in nature, or substance, or quality, was not defective in all three respects. Moreover, provision for sampling milk in course of delivery was made by the Act.

The Margarine Act, 1887, provides that margarine[1] shall not be lawfully sold except under certain conditions. The premises upon which margarine is manufactured must be registered with the local authority (Section 9). Section 7 (4) of S.F.D.A. 1899 extends this requirement to any premises upon which the business of a wholesale dealer in margarine is carried on. All imported margarine, and all margarine forwarded by any public conveyance, must be consigned as such (Section 8). Packages containing margarine must be so marked in letters of a specified minimum size, and where the margarine is exposed for sale by retail a label must also be used, and each package must be delivered in a specially marked paper wrapper (Section 6). There are saving clauses framed on the model of Section 25 of the Food and Drugs Act, 1875, already referred to.

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[1] Section 13 of the Butter and Margarine Act, 1907, defines "margarine" as "an article of food, whether mixed with butter or not, which resembles butter and is not milk-blended butter."

The Sale of Food and Drugs Act, 1899, defines " cheese " and " margarine-cheese," the latter being " any substance whether compound or otherwise, which is prepared in imitation of cheese, and which contains fat not derived from milk." By Section 3, every local authority empowered to administer the Sale of Food and Drugs Acts must appoint a public analyst, and use their powers. In London the borough councils, in the rest of the country, county councils and town councils, are local authorities. It provides (in Sections 2 and 3) for action on the part of the Local Government Board or the Board of Agriculture, with a view to ascertaining whether local authorities are doing their duty and if necessary enforcing its performance. The Commissioners of Customs are empowered to take samples of imported articles and provision is made for the marking, in a conspicuous manner, of certain adulterated and impoverished articles of food (Section 1). The Board of Agriculture is authorised to make regulations as to the analysis of milk, cream, butter, or cheese, specifying what deficiency of any of the normal constituents shall raise a presumption until the contrary is proved that the article is not genuine or is injurious to health (Section 4). Section 5 extends provisions relating to margarine to margarine-cheese, and Section 8 prohibits the manufacture, sale, or importation of margarine containing more than 10 per cent. of butter-fat. Section 14 extends the power of sampling, in course of delivery, to other articles besides milk, but only on a request from, or with the consent of, the purchaser or the consignee. Moreover, a portion of any sample of milk taken in course of delivery must be sent to the consignor. Vendors of milk and cream must exhibit their name and address on the vehicle or receptacle from which the milk is sold. Section 11 provides that condensed, separated, or skimmed milk shall not be sold or exposed for sale except in receptacles labelled so that the words are clearly visible to the purchaser. Section 16 imposes a heavy penalty for obstructing, or attempting to bribe, an inspector ; and Section 17 increases the maximum penalty in the case of second and subsequent convictions for offences against the Act.

A prosecution is not to be instituted in test cases after the expiration of 28 days from the purchase of a sample and the summons must state particulars of the offence or offences alleged, also the name of the prosecutor, and it is not to be made returnable in less than 14 days from the day on which it was served. A copy of any analyst's certificate is to be served with the summons. Section 20 gives the conditions under which a warranty or invoice will be a defence, and a penalty is provided for a false warranty. On the request of either party the justices or court shall cause the article of food or drug to be sent to the Commissioners of Inland Revenue for analysis and may do so without such request. A defendant may rely on the certificate of a public analyst, who may, however, be required to give evidence.

The Butter and Margarine Act, 1907, gives definitions of the terms "butter factory," and "milk-blended butter," and extends to butter factories, and milk-blended butter factories the provisions of the Margarine Act, 1887, as regards registration with the local authority, and the provision of Section 7 of the Sale of Food and Drugs Act, 1899, for the register of consignments. Premises used for a butter factory must not communicate directly with premises used as a margarine or milk-blended butter factory.

The supervision of all these factories is divided between the Ministry of Health, the Board of Agriculture, and the local authority. Factory butter or margarine shall not contain more than 16 per cent. of water, nor milk-blended butter more than 24 per cent. Section 5 extends the list of articles which may not be imported. Section 7 gives power to the Ministry of Health to frame regulations to determine the use and proportion of preservatives in the manufacture, etc., of butter, margarine, and milk-blended butter.

The Milk and Cream Regulations, 1912 *and* 1917—In the year 1906, the Local Government Board addressed to local authorities a circular in which they discussed the presence of preservatives in milk, and gave it as their opinion that milk need not and should not contain preservatives. In particular they called attention to the danger entailed by the use of formalin, both in respect of the action of formalin on the digestive system, and as indicating that the milk so treated had become injurious in itself.

In 1912, the Board issued the Milk and Cream Regulations under Section 1 of the Public Health (Regulations as to Food) Act, 1907. Medical officers of health are expected to exercise personal supervision over the action taken in pursuance of the regulations. They require that *no* preservative shall be added to milk (a term which includes skimmed, separated, condensed and dried milk) nor to cream which contains less than 35 per cent. by weight of milk fat. Cream which contains 35 per cent. or more, may be treated with boric acid or borax, or a mixture of these preservative substances or with hydrogen peroxide. If treated with boric acid or borax it must contain not more than the equivalent of 0·4 per cent. boric acid by weight.

No person shall sell or expose for sale or have in his possession for the purpose of sale, any cream to which any thickening substance has been added in contravention of the provision of Subdivision 1 of this Article. " Thickening substance " means sucrate of lime, gelatine, starch paste or any other substance which when added to cream, is capable of increasing its thickness. Every vessel containing preserved cream must have a label showing in letters of equal and prescribed size " preserved cream " and stating as the case may be with boric acid or hydrogen peroxide, and in the case of the former the percentage. (In the case of a restaurant, etc., it suffices if the equivalent statement is shown conspicuously in the room, and if the cream is put up in a cardboard box, these words may be printed on the box.)[1]

These regulations are administered under the Public Health Acts, and under sections which impose a very heavy penalty. It is therefore advised that offenders be summoned before the Public Health Committee, and requested to offer an explanation. Only in the case of grave offences would a prosecution be instituted in the first instance. Samples are taken with the usual procedure under the Sale of Food and Drugs Acts, but the Board advise that any legal action should be taken under the Regulations. If a prosecution is instituted under the regulations, the analyst's certificate is not evidence, and his personal attendance at court is necessary. The medical officer of health is required to make an annual return on a prescribed form, which he is requested to send to the Ministry early in the year showing the action taken under the regulations in the previous year.

The Milk and Dairies (Consolidation) Act, 1915, which by the Milk and Dairies (Amendment) Act, 1922, is not to come into operation before the first day of September, 1925, contains important provisions bearing on the administration of the Sale of Food and Drugs Acts. By Section 1 (k) the Ministry of Health may make general or special orders for prohibiting the addition of colouring matter, and for prohibiting or regulating the addition of skimmed or separated milk or water or any other substance to milk intended for sale for human consumption, or the abstraction therefrom of butter-fat or any other constituent, and prohibiting or regulating the sale for human consumption of milk to which such an addition, or from which such abstraction has been made, or which has been otherwise artificially treated. Sections 8 and 9 provide for co-operation between medical officers of health of different districts ; in taking and examining samples of milk on information supplied by one medical officer of health to the other such samples may be made available for the purposes of the Sale of Food and Drugs Acts, if in taking the samples all the formalities of these Acts have been complied with. This may be possible when the offices of the public analyst and the public bacteriological laboratory adjoin. In any case the principal matter, so far as the Sale of Food and Drugs Acts is concerned as regards samples taken from the cows, will be the procedures adopted to see that the cows are thoroughly milked and the milk properly mixed. The third schedule of the Act amends the Sale of Food and Drugs Acts, so as to permit the results of analysis of samples taken from a purveyor of milk being controlled by samples taken in transit from the consignor and followed to the cows, if the owner of the cows so desires. In those cases in which the milk sampled in the first instance is mixed milk of different consignors the sample will have to be adjudged on the minimum standard fixed by the Board of Agriculture, *viz.*, 3 per cent. fat and 8·5 per cent. of solids not fat. As the Act provides that in taking samples the local authority is only to take samples in its own district, the procedure hitherto adopted of following samples to the cows will no longer be available.

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[1] If the draft Public Health (Preservatives, etc., in food) Regulations 1925, are confirmed in their present form no preservative will be allowed in cream.

Evasions of the Sale of Food and Drugs Acts are numerous and ingenious, especially in regard to milk. The easiest and no doubt the most practised is the readjusting of milk so as to comply with the standard of the Board of Agriculture. Accidents are very liable to happen to it in the course of manipulation, such as a leak in the refrigerator. Cows are apt to assume an impoverished condition if it is desired to retain the fatty contents, and water has an unfortunate habit of lingering in the pail by accident. Clause 9 (3) of the Milk and Dairies (Amendment) Act, 1922, suggests possibilities. "A person shall not be convicted of any offence under any enactment relating to the sale of milk in respect of a sample of milk taken after the milk has left his custody and control, if it is proved to the satisfaction of the court that the churn or other receptacle in which the milk was contained was effectively closed and sealed at the time when it left his custody and control, but was not so closed and sealed at the time when it reached the person by whom the sample was taken."

Milk and Dairies (*Amendment*) *Act*, 1922—Section 2 empowers a local authority under certain conditions to refuse to register a retail purveyor of milk, or to remove such a person from the register.

In considering the effect of this section, reference should first be made to Article 6 of the Dairies, Cowsheds and Milkshops Order of 1885 and to Subsection (3) of the present section.

The Order in question requires every sanitary authority to keep a register of persons from time to time carrying on the trade of cowkeepers, dairymen or purveyors of milk and provides that a person may not carry on the trade unless he is registered. This Order required the authority to register every person carrying on the trade and gave them no power to refuse to register any person or to remove him from the register.

Section 2 (3) of the new Act provides that the Order is to have effect so as to require two registers to be kept, the one being restricted to retail purveyors and the other containing all other persons registered under the Order (*i.e.*, wholesale traders and producers who do not sell milk by retail); and Section 2 (1) empowers the local authority to refuse to enter any person on the first of these registers or to remove him from that register if they are satisfied that the public health is or is likely to be endangered by any act or default of his in relation to the quality, storage or distribution of milk.

Section 2 (2) empowers the court before whom any retailer is convicted of an offence relating to milk or dairies, in addition to any other penalty, to remove him from the register for such period as the court may think fit.

It will be observed that in any case the removal from the register may be absolute or in respect of specified premises; this will enable the authority or the court to distinguish between cases in which the defect is one of general methods and those in which it has relation only to the suitability of particular premises or the methods practised thereat.

Section 4 continues and extends the provisions of an existing Order of the Food Controller. The section prohibits the addition of any colouring matter or water, or re-constituted milk, or skimmed or separated milk, to milk intended for sale. This will enable local authorities to deal with cases in which such additions are made for fraudulent purposes but difficulty is experienced in proving that the mixture is sold as milk.

The section also prohibits the sale of re-constituted milk as milk.

Section 5 imposes a heavy penalty on any person who sells the milk of a cow suffering from tuberculosis of the udder where it is proved that he knew, or could have ascertained by ordinary care, that the cow was suffering from that disease. The maximum penalty for a second or subsequent offence is a fine of £100 or imprisonment with or without hard labour for a period of six months, or both such fine and imprisonment.

Section 10 states that the enforcing authorities are the same as those at present concerned with the enforcement of similar provisions in the existing law. The section also provides out of what rate or fund the expenses of the local authority shall be paid.

Section 11 deals with the case of failure of a local authority to perform any of their duties under the Act, and makes provision for the transfer of powers or duties from a defaulting district council to the county council.

The Sale of Food Order, 1921, made by the Board of Trade, contained provisions relating to the weight of bread and tea, the labelling of imported produce, the composition and labelling of jam and marmalade and the manufacture and sale of fats. The administration of Parts I. and II. of the Order dealing with bread and tea was assigned to local authorities for the purposes of the Weights and Measures Acts, and the administration of Parts III., IV. and V., dealing with imported produce, jams and fats, was assigned to local authorities authorised to appoint an analyst under the Sale of Food and Drugs Acts. The only provisions of the Order enforceable by the authorities directly concerned with the Sale of Food and Drugs Acts which remain in operation are those relating to the labelling of imported meat and eggs which, by the Expiring Laws Continuation Act, 1924, has been extended to December 31, 1925.

HOUSING

Housing of the Working Classes Acts, 1890, 1900, 1903, 1909, 1919, 1919 (Additional Powers), 1923, 1924 (Financial Provisions) and 1925 [1]—The Act of 1890 consolidates and amends three groups of enactments—The Labouring Classes Lodging Houses Acts, 1851 to 1867, known as Lord Shaftesbury's Acts; The Artisans' and Labourers' Dwellings Acts, 1868 to 1882, known as Torrens's Acts; and the Artisans' and Labourers' Dwellings Improvement Acts, 1875 to 1882, known as Cross's Acts. The Act also consolidates the greater part of the Housing of the Working Classes Act of 1885.

Part I. of the Act of 1890, Section 4, makes provision for action to be taken by a "local authority" [2] upon an "official representation" (by a medical officer of health as defined in Section 5) to the effect that within a certain area in the district of such authority either—

(*a*) Any houses, courts, or alleys are unfit for human habitation; or,

(*b*) The narrowness, closeness, and bad arrangement, or the bad condition of the streets and houses or groups of houses within such area, or the want of light, air, ventilation, or proper conveniences, or any other sanitary defects, or one or more of such causes, are dangerous or injurious to the health of the inhabitants either of the buildings in the said area, or of the neighbouring buildings; [3]

and that the evils connected with such houses, courts, or alleys, and the sanitary defects in such area, cannot be effectually remedied otherwise than by an improvement scheme for the re-arrangement and reconstruction of the streets and houses within such area, or of some of such streets and houses.

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[1] The Housing and Town Planning Acts, 1890–1919, are consolidated in the Consolidation Acts of 1925.

[2] The first schedule of the Act specifies the local authority in each particular case. The urban authorities in urban districts (and the Corporation in the City of London) are local authorities throughout the Act. For the purposes of Parts I. and III. the County Council is the local authority in the County of London; for the purposes of Part II., in London, the vestries and district boards (now borough councils), and for the purposes of Parts II. and III., in rural districts the rural authorities (rural district councils) are the local authorities.

[3] Under the earlier Act of 1875 the representation was to state "that diseases indicating a generally low condition of health amongst the population have been from time to time prevalent, and that such prevalence was attributable, etc., etc."

A medical officer of health must make such an "official representation" whenever he sees cause, and he must inspect and report upon any area to which his attention is directed by two justices of the peace, or twelve or more ratepayers. If he fail to inspect or report, or decide that the area is not an unhealthy area, there is an appeal (Section 16) to the confirming authority, the Local Government Board (in London, the Home Secretary). Again, if the local authority fail or decline to take action upon the "official representation," they must state their reasons for not acting to the confirming authority, which may direct an inquiry to be made into the circumstances of the case. If, however, the local authority be satisfied of the truth of the representation, and of the sufficiency of their resources, they may pass a resolution declaring the area an unhealthy area, and may prepare a "scheme" for its improvement.

Schemes under Part I.—The scheme must be accompanied by maps, particulars, and estimates; it may include any number of areas, but must not deal with an area comprising less than ten houses (Section 72, Part IV.). It need not relate to all the property represented, and may include any "neighbouring lands" necessary for making the scheme efficient for sanitary purposes. The scheme may provide for the improvement being effected with the co-operation of the freeholders, under the control of the local authority.

Section 11 relates to the housing of displaced persons while the new housing accommodation is being erected. It has been repealed by Section 33 of the Housing, Town Planning Act of 1919 and now there is no obligation in London (or in the provinces) for a local authority to make such provision. "But it is open to the Ministry of Health to require the scheme to provide for the accommodation of such number of the displaced working classes in suitable dwellings to be erected in such place or places either within or without the area as the Ministry on a report made by the officer conducting the local inquiry may require."[1]

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[1] "Housing in England and Wales," W. A. Willis, 1919, p. 34. The expression "labouring class" was originally defined by Standing Orders of both Houses to include "mechanics, artisans, labourers, and others working for wages, hawkers, costermongers, persons not working for wages but working at some trade or handicraft without employing others, except members of their own family, and persons other than domestic servants whose income does not exceed an average of thirty shillings a week, and the families of any such persons who may be residing with them."

This definition was applied to the "working class" by the Act of 1903, and with the substitution of the words "three pounds" for "thirty shillings" was adopted as the definition of "working class" in the Act of 1923.

"For the purpose of providing accommodation for persons of the working classes displaced 'in consequence of'[1] any improvement scheme, the local authority may appropriate any lands for the time being belonging to them which are suitable for the purpose, or may purchase by agreement any such further lands as may be convenient[2] and land acquired under Part III. of the Act may also be used."[3]

The Act of 1890 states that the local authority may not itself undertake the erection of dwellings, save with the consent of the confirming authority, and must sell or dispose of all such dwellings within ten years of their completion, unless the confirming authority otherwise determine. When a scheme has been prepared, and approved by the local authority, advertisement of the fact must be made for three consecutive weeks in September or October or November, and notices of the scheme must be served upon persons whose interests it is proposed to compulsorily acquire. Application is then made to the confirming authority; a local inquiry is held by a commissioner, and upon his report a "Provisional Order" may be made sanctioning the scheme, with any modifications which are deemed necessary; it is usual for the Secretary of State to require that all plans of dwellings shall be approved by him. The Provisional Order must be subsequently confirmed by Act of Parliament and compulsory powers for the acquirement of property must be exercised within three years of the passing of the Act confirming the scheme.

In assessing the compensation to be given no additional allowance is made for compulsory purchase in regard to any unhealthy portion of the area (portions coloured red), but 10 per cent. above the market value is, as a rule, given in the case of the remaining portions, if any, of the area (parts coloured blue). If no agreement is arrived at by the parties the case is adjudicated upon by an arbitrator appointed by the confirming authority. The special provision which guides the arbitrator's decision is contained in Section 21, which prescribes that no additional allowance shall be made in the case of property which the arbitrator deems to form a part of the unhealthy area, and that no addition shall be made for improvements to property made after the date of advertisement of the scheme, unless such improvements were necessary for the maintenance of the property in a proper state of repair.

Section 21, subsection (2), further states that evidence may be tendered to the arbitrators to prove—

(1) That the rental of the house or premises was enhanced by reason of the same being used for illegal purposes, or being

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[1] See Act of 1909, s. 46 and Sched. II.

[2] Act of 1890, s. 23.

[3] Act of 1900, s. 4.

so over-crowded as to be dangerous or injurious to the health of the inmates; or,

(2) That the house or premises are in such a condition as to be a nuisance within the meaning of the Acts relating to nuisances, or are in a state of defective sanitation, or are not in reasonably good repair; or,

(3) That the house or premises are unfit, and not reasonably capable of being made fit, for human habitation;

and if the arbitrator is satisfied by such evidence, then the compensation—

(*a*) Shall, in the first case, so far as it is based on rental, be based on the rental which would have been obtained if the house or premises were occupied for legal purposes, and only by the number of persons whom the house or premises were, under all the circumstances of the case, fitted to accommodate, without such over-crowding as is dangerous or injurious to the health of the inmates; and

(*b*) Shall, in the second case, be the amount estimated as the value of the house or premises if the nuisance had been abated, or if they had been put into a sanitary condition or into reasonably good repair, after deducting the estimated expense of abating the nuisance or putting them into such condition or repair, as the case may be; and

(*c*) Shall, in the third case, be the value of the land and of the materials of the buildings thereon.

Provision is made for appeal against the arbitrator's award when the amount of compensation exceeds £1,000. The arbitrator's costs are payable by the local authority, and the arbitrator may himself order the local authority to pay the costs of arbitration of the other party, where the award is for a greater sum than was offered by the local authority in respect of the claim before the appointment of the arbitrator.

Part II. of the Act of 1890 applies to rural as well as urban districts; it relates to unhealthy dwellings, to obstructive dwellings, and to the carrying out of small improvement schemes. The confirming authority, as regards schemes under this part of the Act, is the Local Government Board. In London, if the county council consider an area too small to be dealt with under Part I., and suitable for improvement under Part II., or if, on the other hand, it is urged by the district authority that a scheme is of importance to the metropolis as a whole, and should be dealt with under Part I. rather than under Part II., the Secretary of State is empowered to hold a local inquiry and decide the question. The county council may prepare schemes under Part II., and apply to the Secretary of State to require a contribution to be made towards the cost by the district authority, and similarly the latter may apply for a contribution from the county council.

Schemes under Part II.—The procedure under this part of the Act is somewhat simpler than under Part I. The Local Government Board, after local inquiry, issue a Provisional Order, upon which, if no person interested petitions against the scheme within two months, follows a Confirming Order; should such a petition, however, be presented, and not withdrawn, a special Act of Parliament is necessary, as in the case of schemes under Part I. The Local Government Board may require such amount of re-housing provision to be made as they deem necessary in the circumstances of the case, and before sanctioning the scheme the Board requires to be satisfied as to the plans of the dwellings it is proposed to construct. Under Part II. "neighbouring lands" cannot be taken; the compensation provisions are similar to those in Part I., but the arbitrator may take into account any benefit which may accrue by the execution of the scheme to other dwelling-houses of the same owner, and the arbitrator's award is final and binding on all parties.

As regards *Buildings unfit for human habitation*, the Act provides (Section 30) that "it shall be the duty of the medical officer of health of every district to represent to the local authority of that district any dwelling-house which appears to him to be in a state so dangerous or injurious to health as to be unfit for human habitation."

Local authorities are also required to cause inspection of their districts to be made with a view to ascertaining whether any such dwelling-houses exist, and they may, if satisfied that any dwelling is unfit for habitation, take proceedings against the owner to close such dwelling, under the enactments set out in the third schedule of the Act. It should be noted that the term "owner" under this Act does not include landlords holding the premises for a term of which less than twenty-one years are unexpired. When a "Closing Order" has been made, and has not been determined by a further Order, the local authority may, after hearing the objections (if any) of the owner, and if they are of opinion that the "continuance of any building, being part of the dwelling-house, is dangerous or injurious to the health of the public or of the inhabitants of the neighbouring dwelling-houses" make a "Demolition Order." There is an appeal against such an Order to Quarter Sessions.

On written complaint from four or more householders the medical officer of health must inspect and report upon any particular house, and if within three months after receiving such report the local authority takes no proceedings, the householders (save in London or in rural districts where the county council can act in default of the local authority) may petition the Local Government Board for an inquiry.

Obstructive Buildings—Under Section 38 power is given to a local authority to proceed on the report, of the medical officer of health or four or more householders, to the effect that a building, although not in itself unfit for human habitation, is so situate that by reason of its proximity to or contact with any other buildings, it either (*a*) stops ventilation or otherwise conduces to make them unfit for habitation, or (*b*) prevents proper measures being carried into effect for remedying any nuisance injurious to health or other evils complained of in respect of such other buildings. This section was designed to enable the local authority to purchase houses for opening up alleys, etc. If the authority decide to proceed they can make an Order for demolition, subject to appeal to Quarter Sessions. The compensation to be paid is settled by arbitration in case of difference, and where, in the opinion of the arbitrator, the demolition of an obstructive building adds to the value of other buildings, he may apportion a part of the cost of the demolition amongst such other buildings respectively, the said expenses being defrayed by improvement rates levied on the occupiers. This obstructive building section has been hitherto allowed to remain practically a dead letter.

Part III. of the Act may be adopted by local authorities ; in the case of a rural authority the consent of the county council to such adoption is necessary. The authority can then compulsorily acquire land within its district for the purpose of erecting lodging-houses for the working classes.

The Amending Act of 1900 allows any urban sanitary authority which has adopted Part III. of the Act of 1890 to establish or acquire lodging-houses for the working classes outside their district, and a county council may, after careful inquiry and consideration, allow any rural sanitary authority to adopt Part III. of the Act of 1890, and may act in default of the district council, either as regards adopting or enforcing their part of the Act, after due inquiry. Section 62 of the Act of 1890 provides that the " local authority may make by-laws for the management, use, and regulation of the lodging-houses."

Part IV. of the Act of 1890 contains certain supplemental provisions, notably Section 75, which provides that " in any contract made after the fourteenth day of August, 1885, for letting, for habitation by persons of the working classes, a house or part of a house, there shall be implied a condition that the house is, at the commencement of the holding, in all respects reasonably fit for human habitation."

Housing of the Working Classes Act, 1903—Section 1. The maximum period for repayment of money borrowed under the Housing Acts is extended to 80 years. Section 2 transfers powers of Home Office relating to housing to the Local Government Board. Section 4 contains provisions on the failure of a local authority to make a scheme.

Housing, Town Planning, etc., Act, 1909—Section 1 enacts that Part III. of the 1890 Act is to take effect without adoption. Section 12 empowers a county council to act in default of a rural district under Part III. of the principal Act. Section 13 enables a county council if they deem it expedient to exercise the powers of the rural district council under the said Part III. Sections 17 and 18 enact that in future the local authority is to make a demolition order, thus superseding the old procedure of serving notices and the applying to a magistrate for an order; the owners have a right of appeal to the Ministry of Health. Sections 14 and 15 empower the local authority to serve notices and act in default in cases where houses are not "in all respects reasonably fit for habitation"; they are thus enabled to deal with structural defects in addition to health nuisances. The powers under these sections have been extended by Section 28 (Act of 1919) and Section 10 (Act of 1923). Section 36 gives additional powers of entry. Section 43 prohibits the building of back-to-back houses. Part II. of this Act relates to town planning.

Housing, Town Planning, etc., Act, 1919—Section 12 extends powers of local authorities enabling them to obtain possession of houses and to enlarge, alter and amend them. Power is given to the Ministry of Health to override local by-laws. Section 26 amends the law relating to houses let in lodgings. In London the by-laws are to be made by the county council, the borough councils enforcing them. Section 27 gives county courts power to grant permission for houses in neighbourhoods which have changed in character to be converted into tenements. Part II. of this Act relates to town planning.

Housing, Town Planning, etc., Act, 1919 (Additional Powers), provides for grants to persons building their own houses and for two years prohibits building operations likely to interfere with provision of dwelling-houses.

Housing, etc., Act, 1923, mainly relates to encouraging provision of new houses. Section 14 amends Section 26 of the Act of 1919 as regards London, repealing by-laws under Section 94 of the P.H. (Lond.) Act, 1891, thus limiting application of by-laws to working-class houses, but allowing a borough council to enforce special by-laws in other houses let in lodgings if it so desires.

Housing (Financial Provisions) Act, 1924, provides for a programme extending over a period of 15 years and aims at the production at a gradually increasing annual rate of about 2,500,000 houses in Great Britain. See Circular 520.

An increased Exchequer contribution, in other words a larger subsidy, is available for houses subject to special conditions as to their letting and the amount of rent charged. Reasonable preference is to be given to large families in letting houses. The size of the houses or flats and their rooms is laid down in the Regulations.

Section 7 (*b*) lays down that the rate of density, ascertained in such manner as the Minister may determine will not, except with the consent of the Minister, exceed 8 per acre in an agricultural parish and 12 per acre elsewhere.

Relaxation of the by-laws will be permissible in the case of houses eligible for subsidy under the Acts of 1923 and 1924. County Councils may advance loans to builders and others for the construction of houses.

While the Housing of the Working Classes Act, 1890, remains as the foundation on which housing legislation and procedure rest, considerable modification has been made as regards details and a coherent scheme has emerged under which it is anticipated that a vast improvement will be attained in the conditions of future housing.[1] Under this scheme, in the first place, there is to be constant supervision and frequent investigation by all local authorities into the considerations of housing with full records of the state of individual houses. Every local authority is to be responsible for seeing that no houses unfit for human habitation are permitted to remain in their district and that all such houses are rendered fit or closed and where necessary demolished. The removal of slum areas has been facilitated, at all events, so far as machinery is concerned, though the clearance of such areas is necessarily dependent on the antecedent provision of a sufficient number of habitable houses to render the closure of houses reasonably possible.

In the second place, it is the duty of every local authority to ascertain from time to time the needs of their area in respect of the number of houses fit for habitation, available for the working classes. Within three months of the passing of the Housing and Town Planning Act, 1919, and thereafter at fixed intervals or as occasion may require, every local authority must frame and submit to the Ministry of Health a scheme for meeting the needs of their area.

In connection with the important duties devolving on county councils in relation to housing, the Act of 1901 required that every county council should appoint a medical officer of health, who was to be a whole-time officer, was not to be appointed for a limited period only, and was removable only with the consent of the Local Government Board. The county council must also establish a Public Health and Housing Committee.

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[1] The two volumes of the Ministry's manual on unfit houses and unhealthy areas give a complete conspectus of the policy to be pursued, and the various steps to be taken, and formalities to be gone through in dealing with all questions relating to housing. Under Section 41 of the Act of 1909, the Local Government Board issued "The Housing Acts (Form of Orders and Notices) Order, 1919" which prescribes in their proper order the Forms of Representation, Closing Order, Demolition Order, appeals, etc. This Order is available separately, but is contained in Volume ii, which also contains the suggested forms of procedure in order to be followed in connection with improvement schemes.

Another useful Manual, also published in 1919, deals with the conversion of houses into flats for the working classes.

In the third place, in the provision of new houses much thought and effort has been expended by architects, social reformers, and by the Architectural Department of the Ministry, on the development of building sites so as to secure that in future houses shall not be crowded on area and that the sites of the houses shall be carefully chosen so that the houses themselves shall not be crowded on site, shall enjoy abundance of sunlight, shall be planned to be as convenient internally as possible, and shall have a fair amount of garden attached to them. Economy as well as convenience and amenity are to be consulted in the lay-out of streets. These advantages are to be obtained by good town planning and by the example of good housing schemes under the Ministry's assisted housing schemes, which will serve as models for future developments.

Fourthly, during the War the deficiency of houses both actual and prospective as the result of disrepair had greatly increased, so much so that the shortage was estimated by local authorities in 1919 at 800,000 houses. Fresh legislation was therefore passed preliminary to an effort by the Ministry of Health to meet housing needs; a large number of houses were to be built with the aid of the Ministry; this number was later reduced to 176,000. The number of houses was, in general, not to exceed 12 to one acre in urban and 8 in rural districts, and the types of houses were to be guided but not controlled by plans provided by the Ministry.

Fifthly, there are the Town Planning Acts, to be referred to later, which are designed to secure that in future the development of districts shall proceed in an orderly manner so as to avoid congestion and the haphazard arrangement and in accordance with principles which have been worked out to secure amenity and economy.

Spaces will be marked out for public parks, open spaces and public buildings. Interesting historical features will be preserved. The interests of industry and commerce will be consulted in the lay-out as well as those of residents.

OTHER MEASURES IN ASSISTANCE OR RELIEF OF HOUSING SCHEMES, OF THE PRESENT HOUSING STRESS OR OF LOCAL AUTHORITIES IN CARRYING OUT THEIR DUTIES UNDER THE ACTS.

(*a*) In order to guide local authorities in the preparation of housing schemes, the Local Government Board in 1919 published a Manual on the preparation of State-aided housing schemes, which set forth the principles to be adopted in the choice of sites, deals with the lay-out, giving illustrations, discusses drainage and construction, furnishes a list of the successive formal steps to be taken by a local authority in the preparation and completion of a scheme, prescribes the forms to be used at various stages and provides a model set of suggested plans of houses.

The acquisition of land for housing purposes was facilitated under Sections 12 and 15 of the Act of 1919, and Section 10 of the Housing (Additional Powers) Act, 1919, gave facilities for the acquisition of land for town-planning schemes and garden cities.

(*b*) *Building Materials*—Assistance has been given by the Director of Building Materials Supply, Ministry of Health, in procuring building materials, under certain conditions, which it is considered has resulted in a saving of 50 per cent.

(*c*) *Relaxation of Building By-laws*—By the Act of 1919 the building by-laws of an authority do not apply to the construction of streets and houses under an assisted scheme, and a local authority may allow relaxation of the by-laws outside of the assisted schemes to a like extent and under like conditions. The " Relaxation of Building By-laws Regulations, 1920," define the extent of the relaxation of building by-laws which may be permitted by a local authority for three years from July, 1919, outside the assisted housing schemes.

(*d*) *Prohibition of Closure or Demolition or Use for Business Purposes of a Dwelling*—By Section 15 of the Act of 1909, if a local authority considers that a house is not in all respects reasonably fit for human habitation, instead of closing the house they may serve a notice on the landlord to execute the works necessary to render it fit, and instead of compliance the landlord might close the house. In 1919 it became very often his interest to take this course. But by Section 6 of the Housing (Additional Powers) Act, 1919, he was prohibited from doing so unless the house is not capable, without reconstruction, of being rendered fit; this section, however, is no longer in force.

During the War it was found necessary to pass the Mortgage and Rents Restrictions Acts with a view to secure possession to tenants of their houses.

The Increase of Rent and Mortgage Interest (Restrictions) Act, 1920, provides that the increase of rent permitted by that Act shall not take place if the sanitary authority on the application of the tenant certifies that the house is not fit for human habitation, or is not in a reasonable state of repair, nor in any case until or in respect of any period prior to the expiry of four clear weeks after the landlord has served upon the tenant a notice in writing of his intention to increase the rent, and informing the tenant of his right to apply to the sanitary authority for such a certificate as aforesaid. A fee of one shilling is payable to the sanitary authority, but if the authority issues such a certificate the tenant may deduct the fee from any subsequent rent. This section has been much used. Under the 1923 Act the work required to be done must be specified.

(e) *Assistance to Private Builders*—By Section 12 (2) of the Act of 1919 the purpose for which land may be acquired under Part III. of the Act of 1899 shall be deemed to include—

(*a*) The lease or sale of land under the powers conferred by this Act with a view to the erection thereon of houses for the working classes by persons other than the local authority.

(*b*) The lease or sale of land for purposes incidental to the development of the estate, such as the provision and maintenance of houses and gardens, factories, workshops, places of worship, places of recreation, etc.

Local authorities are thus enabled to facilitate the acquisition of land by private persons under conditions. By Section 12 (3) subject to the consent of the Ministry of Health, a local authority may contract for the purchase by or lease to them of houses suitable for the working classes whether built or to be built. They may thus take over the houses after they are built.

By Section 1 of the Housing (Additional Powers) Act, 1919, Parliament provides a sum of £15,000,000 out of which subsidies are to be paid to private builders, under conditions prescribed by the Ministry but only in respect of houses built within 12 months of December 23, 1919. Reduced subsidies are payable only in respect of houses completed and approved within a further 4 months.

By the Housing Act, 1921, the period of 12 months is extended to 2 years and 6 months. In the absence of such assistance, it is not to be anticipated that a material contribution will be made to private builders in reduction of the housing shortage unless and until the demands of industry and commerce are satisfied and until the Rents Restriction Acts are repealed.

In the case of private builders, the subsidy takes the form of a grant of prescribed amount for each class of house, and is paid on submission to the Ministry of the two certificates A and B given by the local authority. The houses must comply with "conditions prescribed by the Ministry of Health as to the planning and construction of houses in respect of which grants may be paid under Section 1 of the Housing (Additional Powers) Act, 1919." Certificate A is furnished by the local authority when plans, sections and methods of construction are submitted. Certificate B certifies that the houses have been completed fit for occupation in a proper and workmanlike manner, and fulfil all the conditions prescribed.

Section 7 of the Housing Act, 1921, enables the Public Works Loan Commissioners to make loans to authorised associations up to an amount approved by the Treasury, for the development of garden cities.

TOWN PLANNING

By the Housing Act of 1909 permission was given to make a town-planning scheme ; as seen above, the duty to make a scheme was laid down by the Act of 1919. The intention of a town-planning scheme was set out in the Act of 1909 which enacted that a scheme may be made as respects any land which is in course of development or appears likely to be used for building purposes with the general object of securing proper sanitary conditions, amenity and convenience in connection with the laying out and use of the land and of any neighbouring lands. Land likely to be used for building purposes "shall include any land likely to be used as, or for the purpose of providing open spaces, roads, streets, parks, pleasure grounds, etc.," and the decision of the Local Government Board as to whether land is likely to be used for building purposes or not, shall be final. The Local Government Board may authorise the inclusion in the scheme of land already built upon, or not likely to be used for building purposes and provision for the demolition or alteration of any buildings thereon. The Local Government Board may prescribe a set of general provisions (or separate sets of general provisions adapted for areas of any special character), for carrying out the general objects of town-planning schemes, and shall insert special provisions defining the town-planning area, the authority who are to be responsible for the scheme, and clauses supplementary, excluding or varying the scheme.

The "Responsible Authority" is a term applicable where the scheme relates to land not entirely within the area of one local authority, and when two or more local authorities join to frame a scheme, or form a joint body constituted specially for the purpose of the scheme.

The responsible authority may purchase land for the purpose of a town-planning scheme by agreement, or compulsorily, in the same manner and subject to the same conditions as an urban district for the purposes of Part III. of the Housing of the Working Classes Act, 1890, as amended by Sections 2 and 45 of the Act of 1901.

By Section 61 of the Act of 1919 the Ministry of Health is empowered after holding a public local inquiry to compel a local authority to propose or adopt a town-planning scheme, or to carry into effect a scheme already approved.

Every local authority may by resolution decide to prepare a town-planning scheme and adopt with or without modifications any town-planning scheme proposed by all or any of the owners of land with respect to which the local authority are themselves by this Act authorised to prepare a scheme, provided that if land outside the area is included the permission of the Ministry of Health is required for the preparation of a scheme. Local authorities may join to form a scheme, and for that purpose form a joint committee and delegate to the committee their respective powers. The Ministry may make regulations for the procedure consequent on the resolution of a local authority to prepare a town-planning scheme. In the case of schemes prepared by the council of a local authority within the administrative area of a county council, the county council must be furnished with the resolution of the local authority to prepare a scheme, and is entitled to be heard at any public inquiry held by the Ministry in regard to the scheme. The Ministry may by special or general order provide that where a resolution to prepare or adopt a town-planning scheme has been passed or where before the passing of this Act, the preparation or adoption of a town-planning scheme has been authorised, the development of estates and building operations may be permitted to proceed pending the preparation or adoption and approval of the scheme, subject to such conditions as may be prescribed by the order (Section 45).

The regulations governing the procedures to be followed in the preparation, advertisement, submission, etc., of a town-planning scheme under Section 56 Act of 1909 and Section 43 Act of 1919, form circular 373, 1921, and give in full detail the different steps to be taken. It may be stated generally that, usually a town-planning scheme proceeds in successive stages and with ample notice to all interested authorities and persons, so that at every stage it is submitted to the fullest criticism and discussion. The resolution to prepare a scheme is followed by the preparation of a map No. 1 clearly defining the area to be taken, and is advertised, the advertisement stating where a copy of the resolution and a copy of map (No. 1) are open to inspection ; every step taken by the local authority must be communicated to the Ministry. Usually the next stage is the preparation of a preliminary statement of proposals for development with map No. 2. Supposing this approved by the Ministry it is advertised and in due course a draft of the scheme which must be adopted by resolution within 12 months of the approval of the preliminary statement, along with a map (No. 3), is adopted by the local authority. The draft scheme with map No. 3 is then advertised and exhibited. It is sent to the Ministry and if approved with or without modifications is again advertised, and any final criticisms are taken into consideration. The scheme as finally approved by the local authority by resolution is submitted to the Ministry under seal. A local inquiry is held, and the report of the inquiry considered ; if the scheme is finally approved it is again advertised and open to inspection. The conditions under which development may be allowed to proceed under Section 45 of the Town Planning Act, 1919, are contained in an Order made under that Section and are explained in Memorandum 70 *d*.

A town-planning scheme is usually a work requiring much consideration, technical knowledge, ingenuity and patience, nor is three years too much for its preparation. The future probable development of the area to be planned has to be carefully thought out in relation to its past history, its present condition and the use residential, commercial, industrial that in view of existing circumstances it is likely will be made of the area. These circumstances should be carefully weighed in the framing and presentation of improvement schemes. The relation of probable development of any given area to that of adjoining areas must also be well considered and taken into account in the laying out of main roads so that the needs of commerce and industry may be economically subserved. In the lay-out the zoning [1] of the area must be planned so that due provision may be made for industrial and commercial needs in such a manner as to conserve the amenity and beauty and convenience of the residential portions.

The proportion of land to be allotted to business and its position will not always be easy to determine and the term " zone " will not always represent its position. In some cases this may be a definite sector, in others a side of the area, according to the position of existing developments and the direction of prevailing winds.

In the planning of roads and streets, care must be exercised to obtain the utmost frontage that the land will permit consistently with good planning and also that living-rooms may obtain the maximum of sunlight.

There must also be ample space between the fronts and in the rear of dwellings, and the number of houses in urban areas must not generally exceed 12 to the acre. The size and construction of main roads, secondary roads and streets must be carefully planned and constructed so as to give at once convenience and economy; residential areas are to be so planned as to prevent unnecessary traffic over minor streets.

Canal Boats Acts, 1877 and 1884—Under the Act of 1877 a canal boat used as a dwelling must be registered by a local authority, and can only be so used by persons of the ages and sexes for which it is registered. The registering authority must be the authority of a district abutting on the canal upon which the boat plies, and the boat is to be allocated as belonging to a place within a particular school district. The boat must have painted on it the word " registered," its registered number, and the place to which it belongs.

The Local Government Board is empowered (Section 2) to make regulations concerning questions arising in connection with canal boats, and regulations were accordingly issued in 1878. They prescribe that there shall be at least one dry, clean, weatherproof cabin (an after-cabin intended for use as a dwelling must be of at least 180, and a fore-cabin of at least 80 cubic feet capacity) ; such cabin must have means of ventilation apart from the door, and must provide adequate sleeping accommodation. One cabin is to contain a stove and chimney. There must be provided storage for three gallons of water, and, if the boat carries foul cargoes, the hold must be separated from any inhabited cabin by a double bulkhead with an interspace of four inches ; further, the bulkhead next the cargo must be water-tight. Sixty cubic feet of space are to be allowed for each person over twelve, and 40 cubic feet for each person under twelve. In boats worked by shifts a cabin designed for two persons must contain at least 180 cubic feet. No boy of more than fourteen, and no girl of more than twelve years of age, may sleep in a cabin occupied by a married couple, and males over fourteen and females over twelve must not sleep in the same cabin ; reservation is made for married couples and also (under certain conditions) in respect of boats constructed before the regulations were issued. The interior of a cabin must be kept clean, and repainted every three years. Bilge water must be pumped out daily. The master of the boat must notify any case of infectious disease, and the boat may be detained for purposes of cleansing and disinfection.

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[1] For the manner in which these and other objects of a scheme are to be obtained reference should be made to the report of the Tudor Walters' Committee, published in 1918, and the Manual on State-aided Housing Schemes.

Housing schemes are town-planning schemes in miniature and the principles of town planning are therefore given in the Manual on the Preparation of State-aided Housing Schemes published by the Ministry of Health in 1919.

The Act of 1884 places the duty of enforcing the Acts and regulations, and of reporting annually to the Local Government Board, upon local authorities, through whose districts a canal passes. The Board is, moreover, to appoint inspectors, to inquire as to the working of the Acts and to report annually to Parliament.

Canal boats will no doubt be made the subject of further legislation, though the subject is not an easy one. Conditions vary in different districts, but the following occur : As the boat is constantly shifting about and often forms the habitation the children are often uneducated so far as reading and writing goes. They are said, however, to be healthy and intelligent ; infectious disease is infrequent. The privy arrangements are primitive though not unwholesome. There seems no sufficient reason why a water-closet should not be provided. The arrangements for cooking are often unsatisfactory. Storage for water should be in a tank or other suitable receptacles, inaccessible from deck, as otherwise drinking water is apt to be tampered with. There seems no reason why more light should not be provided in the cabins by deck or door lights. A second ventilating opening would be useful, which might be a louvre in the cabin door.

Factory and Workshop Act, 1901—This Act consolidates, with amendments, all previous Acts [1] relating to factories and workshops.

Definitions—" Factories " include (1) all places in which mechanical power is used in aid of the manufacturing processes ; and (2) all places, whether mechanical power is used or not, in which certain industries specified in Part I. of Schedule VI. of the Act are carried on. " Workshops " include (1) certain places specified in Part II. of Schedule VI., if they are not factories by reason of the fact that mechanical power is used; (2) any other premises (not being factories) in which manual labour is exercised by way of trade or for purposes of gain in or incidental to the making, altering, repairing, ornamenting, finishing, or adapting for sale of any article, and to or over which the employer of the persons working there has the right of access or control; and (3) any workplace (termed in the Act "tenement workshop") in which, "with the permission of, or under agreement with, the owner or occupier, two or more persons carry on any work which would constitute the workplace a workshop if the persons working therein were in the employment of the owner or occupier. This third group is included for the first time under the Act of 1901.

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[1] In recent years important Acts were passed in 1878, 1883, 1891, and 1895.

Laundries do not come within the definitions of factory and workshop; there is a section (103) of the Act which specially relates to them (subject to certain exemptions, as regards laundries in which the persons employed are inmates of prisons, reformatories, etc., or inmates of an institution conducted for religious or charitable purposes, or members of the same family dwelling there, or in which not more than two persons dwelling elsewhere are employed). So far as sanitation and means of escape from fire are concerned, laundries to which the Act applies are to be treated as factories or workshops, according as mechanical power is, or is not, used.

"Workplace" is not defined in the Act; in a case under Section 38 of the Public Health (London) Act, 1891, Bennett *versus* Harding, it was held that "workplace" includes any "place where work is done permanently, and where people assemble together to do work permanently of some kind or other." A stable and stable-yard where men were employed as cab-cleaners and horsekeepers was therefore held to be a workplace. The term has thus wider signification than the term workshop. The kitchens of restaurants, for example, though not workshops, come within the meaning of the term workplace.

The Act of 1901 is divided into ten parts. Part I. deals with Health and Safety; Part II. with Hours of Employment, Overtime, etc.; Part III. with the Education of Children; Part IV. with Dangerous and Unhealthy Industries; Part V. with Tenement Factories, Cotton Cloth, and other Humid Factories, Bakehouses, Laundries, Docks, etc.; Part VI. with Home Work; and the other parts with Administration, Legal Proceedings, etc. Part I. is the most important part of the Act from a public health point of view.

Factories—Under Section 1 every factory must be kept in a cleanly state; must be kept free from effluvia arising from any drain, water-closet, earth-closet, privy, urinal, or other nuisance; must not be so overcrowded while work is carried on as to be dangerous or injurious to the health of the persons employed therein; and must be ventilated in such a manner as to render harmless, as far as practicable, all gases, vapours, dust, or other impurities generated in the course of the manufacturing process or handicraft carried on, that may be injurious to health. Subsection (3) of Section 1 provides, subject to certain powers of exemption (as regards particular classes of factories) given to the Secretary of State, that " all the inside walls of the rooms of a factory, and all the ceilings or tops of those rooms, and all the passages and staircases, if they have not been painted with oil or varnished once at least within seven years, shall be limewashed once at least within every fourteen months, and if they have been so painted or varnished they shall be washed with hot water and soap once at least within every fourteen months."

The administration of these provisions is in the hands of the factory inspector of the district. The duties of district councils in respect to factories are those which relate to means of escape in case of fire, special duties as regards domestic factories and underground bakehouses (similar to those applying in the case of workshops), and, in places where Part III. of the Public Health Acts Amendment Act of 1890 is in force, the enforcement of the requirement, in Section 22 of that Act, as to the provision of suitable and sufficient sanitary conveniences. (See p. 696.)

Domestic factories and workshops are defined by Section 115, the principal distinctions being that power is not used and that the only persons employed are members of the same family dwelling there; cleanliness, ventilation, spacing, are in these administered by the district council. If, however, any work carried on has been certified by the Secretary of State as dangerous the workplace becomes a factory or workshop and is dealt with by the factory inspector.

Workshops—Under Section 2 the provisions of Section 91 of the Public Health Act, 1875, as to cleanliness, overcrowding, and ventilation are to apply to " every factory, workshop, and workplace, except any factory to which the last preceding section (Section 1 of the Act of 1901) applies." These provisions are supplemented (Subsections (2) and (3) of Section 2) by others which relate to freedom from effluvia, and to limewashing and cleansing of workshops on the certificate of a medical officer of health or inspector of nuisances. These requirements and others (Sections 3, 7, and 8), to be presently referred to, are to be enforced by district councils. The provisions of Sections 6 and 9 are not, however, brought under the law relating to public health, and will therefore be enforced by the factory inspectors.

Section 3 defines " overcrowding " in a factory or workshop; 250 feet, or during overtime 400 cubic feet, per person, being the limits prescribed. The Secretary of State, by special order, may modify this proportion for any period during which artificial light, other than electric light, is employed for illuminating purposes. Similarly, the proportion may be modified where a workshop or workplace, not being a domestic workshop, is occupied by day as a workshop and by night as a sleeping-place. Notices specifying the number of persons who may be employed in each room must be affixed in every factory and workshop.

Section 4 empowers the Secretary of State to act in default of the local authority in the event of his being satisfied that the authority have failed to carry out " the provisions of this Act or of the law relating to public health in so far as it affects factories, workshops, and workplaces." Any expense incurred may be recovered from the local authority.

Section 5 empowers an inspector to give notice concerning sanitary defects, remediable under the law relating to public health, to the local authority, who must then take action thereon, and inform the inspector of the proceedings taken; if proceedings are not taken within one month the inspector may himself take proceedings, and may recover his expenses.

Section 6 requires that in every factory and workshop adequate measures must be taken for securing and maintaining a reasonable temperature in each room in which any person is employed. The Secretary of State may, by special order, direct, with respect to any class of factories or workshops, that thermometers be provided in specified positions.

Section 7 stipulates that sufficient means of ventilation shall be provided, and that sufficient ventilation shall be maintained, in every room in any factory or workshop. The Secretary of State may, by special order, prescribe a standard of sufficient ventilation for any class of factories or workshops. There is, moreover, a sub-section (4) dealing with apportionment of cost of providing means of ventilation between owners and occupiers. Workshops where men only are employed are exempted from the operation of this section. (Such workshops are also excluded from the operation of the sections relating to temperature, thermometers, and some other matters, Section 157.)

Section 8 prescribes that in cases where any process is carried on which renders the floor liable to be wet, adequate means of drainage shall be provided.

Section 9 requires sufficient and suitable accommodation in the way of sanitary conveniences to be provided, with proper separate accommodation for persons of each sex. The Secretary of State shall, by special order, determine what is sufficient and suitable accommodation. The section does not apply to London, or to any place where Section 22 of the Public Health Acts Amendment Act, 1890, is in force.

Safety from Fire—Section 14 makes it the duty of a district council (in London, of the London County Council) to see that factories and workshops are provided with sufficient means of escape in case of fire. Every factory of which the construction was commenced after January 1st, 1892, and every workshop of which the construction was commenced on or after January 1st, 1896, must, if more than forty persons are employed, be furnished with a certificate from the district council, to the effect that it is provided with such means of escape as can reasonably be required in the circumstances of the case. The district council must from time to time ascertain as regards all other factories and workshops, in which more than forty persons are employed, whether they are provided with such means of escape from fire as can reasonably be required, and, if they are not, must serve on the owner a notice specifying what should be done. If the owner disagrees the dispute is to be determined by arbitration in the manner prescribed in the Act. Section 15 newly empowers district councils to make by-laws providing for means of escape from fire in the case of any factory or workshop.

In Part IV. (*Dangerous and Unhealthy Industries*), Section 73 provides that every medical practitioner attending on, or called in to visit, a patient whom he believes to be suffering from lead, phosphorus, arsenical or mercurial poisoning or anthrax, contracted in any factory or workshop, shall notify the fact to H.M. Chief Inspector of Factories.[1]

To these diseases, by order of the Secretary of State have been added (1) " toxic jaundice " occurring in a factory or workshop, that is, jaundice due to tetrachlorethane or nitro- or amido-derivatives of benzene or other poisonous substances. Poisoning by arseniuretted hydrogen should be notified under this head. (2) Epitheliomatous ulceration and chrome ulceration due to industrial processes. The Secretary of State may, by special order, apply the provisions of the section to any other disease occurring in a factory or workshop. Sections 74–78 relate to the provision of ventilation, by means of a fan, in particular factories and workshops, with the provision of lavatories, with arrangements as to meals in certain dangerous industries, and with other restrictions imposed in the case of particular trades. Sections 79–86 relate to regulations for dangerous trades, the procedure to be adopted in such cases, inquiries as to draft regulations, etc. " Special rules " have been applied in the past to white lead and other kinds of lead works, to lucifer-match works, and to works in which earthenware and china, explosives, bichromate, etc., are manufactured.

Part V. contains important provisions as to cotton cloth, and other humid factories (Sections 90–96), bakehouses (Sections 97–102), laundries (Section 193), docks (Section 104), etc. As regards *Humid Factories,* the Cotton Cloth Factories Act, 1889, already regulated humidity and temperature in such places, and an amending Act of 1897 contained the provision that the air in humified cotton cloth factories must not contain more than ·9 part of CO_2 per 1,000 parts of air. These provisions are re-enacted in the Factory and Workshop Act, 1901. It is prescribed that the amount of moisture in the atmosphere must not exceed an amount shown in a table (appended in the fourth schedule to the Act) which gives maximum limits of humidity at different temperatures. These provisions are amplified by an Order of the Secretary of State dated March 18th, 1912.

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[1] Recently aniline, carbon bisulphide and chronic benzene poisoning have been made similarly notifiable.

Bakehouses are subject to the general provisions of the Act. They are either factories or workshops, according as mechanical power is or is not used. A general power (Section 98) is given, in the case of premises in such a state as to be on sanitary grounds unfit for occupation as a bakehouse, to bring the case before a court of summary jurisdiction, which may impose a fine and order means to be adopted for removing the ground of complaint. In addition there are other special sections relating to bakehouses, the provisions of which may be summarised as follows :—

Section 97.—A bakehouse must not contain or communicate directly with a water-closet, earth-closet, privy, or ashpit ; a cistern supplying water to a bakehouse must be separate from any cistern supplying water to a water-closet ; again a sewage pipe or drain must not have any opening in a bakehouse.

Section 99.—All inside walls and ceilings of rooms, and all passages and staircases must be limewashed every six months or coated with three coats of paint, or varnish, every seven years, and washed with hot water and soap every six months ; if not, the bakehouse will be deemed not to be kept in conformity with the Act.

Section 100.—Places on the same level with a bakehouse, and forming part of the same building, must not be used as sleeping-places unless effectually separated from the bakehouse by a partition from floor to ceiling, and provided with an external glazed window at least 9 square feet in area, of which 4½ feet must be made to open for ventilation. For a first offence a penalty of £1, and for a second or subsequent offence a penalty of £5 may be imposed, both on the person occupying and on the person letting or knowingly suffering the place to be occupied.

Section 101 provides that " an underground bakehouse shall not be used as a bakehouse unless it was so used at the passing of the Act " ; further, that after January 1, 1904, " an underground bakehouse shall not be used unless certified by the district council to be suitable for that purpose." An underground bakehouse is defined as being one "any baking room of which is so situate that the surface of the floor is more than three feet below the surface of the footway of the adjoining street or of the ground adjoining or nearest to the room." These regulations are to be enforced (Section 102) in the case of "retail bakehouses" by the district council. In London they are enforced by the borough councils in all bakehouses, whether retail or not, which are workshops.

Part VI. relates to *Home Work.* Section 107 requires that lists of "outworkers," in such classes of work as may from time to time be specified by special order of the Secretary of State, shall be kept by occupiers of factories and workshops and contractors employed by them, and shall be forwarded twice yearly to the district council. The council shall furnish particulars as to outworkers employed outside their district to the council of the district in which the place of employment is situated. Section 108 empowers the district council to give notice to employers prohibiting work being done upon unwholesome premises. This power is limited to particular classes of home-work specified by special order of the Secretary of State. Section 109 prohibits the making, cleansing, or repairing, of wearing apparel in places where there is scarlet fever or small-pox, and Section 110 prohibits home-work (of certain kinds specified by special order) in a house any inmate of which is suffering from any infectious disease required by law to be notified to the local authority. Section 111 deals with the application of the Act to domestic factories and workshops.

Section 131 imposes on district councils the duty of keeping a register of workshops in their districts, and Section 132 requires the council's medical officer of health for the future, in his annual report to the council, to report specifically on the administration of the Act in workshops and workplaces (provisions as to sanitation, bakehouses, and home-work), and to forward a copy of his report on the subject to the Secretary of State. It is, moreover, under Section 133, the duty of the medical officer if he finds any woman, young person, or child employed in a workshop in which no abstract of the Act is posted up, to inform the District Inspector of Factories of the fact, in writing.

These further observations may be made on the duties of district councils under the Acts. They are set forth in a memorandum issued by the Home Office (edition 1912), which gives a convenient and complete summary and clearly defines the places and extent to which the jurisdiction of the local authority extends. The memorandum points out that it will greatly facilitate the administration if the council and its officers, when considering the plans of any new building intended to be used as a factory or workshop, will see that all requirements of the Act of a structural character, whether falling to be administered by the local authorities or by the factory inspector, have been met. No doubt this is largely carried out. But it is suggested that all such plans should necessarily be submitted to the medical officer of health, by whom suggestions as to structural alterations should be formulated, so far as factories and workshops, falling to be administered by the council in respect of protection from fire, sanitary conveniences, ventilation and other matters are concerned. These plans, with the suggestions and other plans without suggestions should then be submitted by him to the factory inspector, who would make his suggestions as to the plans and return them to the medical officer of health, who would transmit the plans and suggestions to the surveyor (or council's architect). It is desirable that a statement should then be received by the medical officer of health showing which suggestions have been adopted. It will be seen that in this way no new plans would be passed without revision, while no interference with the functions of the factory inspector would occur, occasionally useful suggestions to architects might be made without friction and the medical officer of health would be kept *au fait* with the important developments in industrial hygiene.[1]

The sanitary provisions of the Act, Sections 97 to 100 (inclusive), are now enforceable by the district council in all bakehouses. (Transfer of Powers Order, 1921.)

By the same Order Section 61 which prohibits the employment of women in a factory or workshop within four weeks after childbirth is similarly transferred. It is expected that the local administration which deals with notification of births will be able to prevent evasion of this provision. Sections 109 and 110 prohibiting homework where there is infectious disease, are formally transferred. Practically they have hitherto been administered by the district council. The administration of Section 9 which requires that every factory and workshop must be provided with sufficient and suitable sanitary conveniences, and of the Sanitary Accommodation Order of 1903 rests with the inspector of factories. It is in fact carried out by the district council under the Public Health Amendment Act, 1890 (Section 22), or the Public Health Act, 1875 (Section 38), the inspector calling attention of the council to any omission or requirement.

It may be assumed that supervision of closets by the council is implied though the cleanliness of factories is the province of the factory inspectors. The Memorandum calls attention under cleanliness to the need to prohibit spitting, a need no less urgent in factories than in workshops.

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[1] For use in connection with the examination of plans valuable papers are :— Memorandum upon the structural requirements of the Factory and Workshop Acts, issued by the Home Office, 1912. On the ventilation of Factories and Workshops, issued by the Home Office, 1920.

The question of supervision of sanitary conveniences arises in connection with the exceptional importance of lighting, ventilation, cleaning, and above all absence of expectorated matter in closets. No doubt the welfare sections of works committees will take this in hand. By the Factory and Workshop Act, 1907, laundries now become factories or workshops according as power is or is not used. The provisions of the Act of 1901, requiring that wet floors shall be drained, and the heating by gas of irons removed from the ironing room or rendered innocuous are extended to workshop laundries, and are administered by the local authority. Institutional laundries are no longer exempt from the Act and become factories or workshops.

Further Developments—The Act of 1901 remains the foundation for formal legislation. Nevertheless, a great change has occurred in regard to the spirit in which almost the whole of its provisions are regarded, and the application of its provisions is preparing the way for fresh enactment. The employees are taking an interest and a part in its enforcement which shows that they realise that health and safety have a high value pecuniarily and otherwise. It is to be hoped that the growth of welfare committees, safety committees, industrial councils and works committees, will produce improved conditions of work. No legislative change has occurred as regards the permissible hours of work, except in regard to children, but actually there has been a general movement towards a 48-hour week. The various investigations into the effects of industrial fatigue have no doubt greatly assisted to bring about this amelioration, but it has also been due to a general determination on the part of workers to secure shorter hours of work. Where work is continuous, the tendency is to the establishment of eight-hour shifts. In other cases orders from the Secretary of State have permitted instead of the periods of work prescribed by the Factory and Workshop Act, 1901, two eight-hour shifts. These and other ameliorations must have a decided effect in improving the health of workers, and the effect on output appears to be generally favourable.

Another beneficial influence has been the continued study of ventilation, which has resulted in great improvements especially in the case of larger factories. To this the researches of Haldane and Leonard Hill have greatly contributed. Of no less moment has been the application of localised ventilation in the case of dangerous processes, largely due to H.M. Inspectors of Factories.

Of much importance, too, have been the widespread provision of well-equipped mess-rooms, canteens, rest-rooms, well-warmed and ventilated cloak-rooms, and adequate lavatories and water-closets. In some cases baths, playgrounds, recreation-rooms, a library, or a gymnasium have been provided. These provisions react on the habits, spirits and health of the workpeople. The following is an outline of the developments which have taken place.

LEGISLATION

The Notice of Accidents Act, 1906, somewhat alters the conditions under which notice of an accident must be sent to H.M. Inspector, and to the certifying surgeon, and prescribes a form of notice and directs that an entry of the accident shall be made on the general register.

Factory and Workshop Act, 1907—By this Act the hours of work are reduced for women. Children may only be employed half-time. Women, young persons, and children may not be employed on Sundays.

A memorandum issued by the Home Office on December 31st, 1907, deals comprehensively with questions of health and safety, it discusses ventilation, lighting, provision of seats where possible, and also of drinking water in certain occupations.

The Factory and Workshop (*Cotton Cloth Factories*) *Act*, 1911, gives power to the Secretary of State to make regulations giving effect to the recommendations contained in the Second Report, dated January, 1911, of the Committee appointed by the Secretary of State to inquire into the question of humidity and ventilation in cotton cloth factories, and to substitute such regulations for the provisions of the principal Act and of its fourth schedule. Regulations were made accordingly to come into force in 1912. These prohibit artificial humidification if the wet bulb reading of either hygrometer exceeds 75° F. and also at the lower end of the scale if at any time after the first half-hour of employment in the day the dry bulb reading is below 50° F. or if within the first half-hour the wet bulb reading is less than 2 degrees below the dry bulb reading, that is to say, chill and deposit of moisture must be avoided at the lower end of the scale, and an excessive temperature with high degree of humidity at the upper end. The requirements previously insisted upon as regards the amount of carbon dioxide present in the atmosphere, are considerably relaxed. Precautions are prescribed to obviate excessive temperature due to direct solar radiation.

Police, Factories, etc. (*Miscellaneous Provisions*), *Act*, 1916—By Section 7 the Secretary of State may make orders (Welfare Orders) for a particular factory or workshop, or for groups or classes to be administered at the expense of the occupier, and may be made contingent in respect of particular requirements on application being made by a specified number or proportion of the workers concerned. They may also provide for the workers concerned being associated in the management of the arrangements in any case where they contribute part of the cost. The Orders relate to these matters : "arrangements for preparing or heating and taking meals, the supply of drinking water, the supply of protective clothing, ambulance and first-aid arrangements, the supply and use of seats in workrooms, facilities for washing, accommodation for clothing, arrangements for supervision of workers."

By Section 8 certifying surgeons are no longer required to investigate the nature and cause of death or injury caused by accidents under the Acts 1901–11, but continue to investigate diseases occurring in factories and workshops and cases of injury caused by exposure to gas, fumes or other noxious substances, or due to any other cause specified in instructions of the Secretary of State as requiring investigation, also any case of injury which the inspector of the district under instructions from the Secretary of State may refer to him.

The Employment of Women, Young Persons, and Children Act, 1920—This and the following Act are passed to carry out conventions adopted at conferences of the International Labour Organisation of the League of Nations at Washington and Genoa. It provides that no child shall be employed in any industrial undertaking ("child" means a person under the age of fourteen years), nor on any vessel, unless only members of the same family are employed therein.

No young person or woman shall be employed at night in any industrial undertaking except so far as set out in Parts II. and III. of the schedule to this Act.

A register of young persons giving the dates of their birth and the dates at which they enter and leave the service of their employer must be kept in connection with every industrial undertaking, every sea-going ship, or boat registered in the United Kingdom as a British ship and for all mines and quarries.

Women and Young Persons (Employment in Lead Processes) Act, 1920, prohibits the employment of a woman or young person in a number of operations concerned with the manufacture of lead and lead compounds or in the cleaning of workrooms where such manufacture is carried on, also except on certain conditions in any process involving the use of lead compounds, if the process is such that dust or fumes are given off or if the workers are liable to be splashed with lead compounds. Amongst the conditions are the provision of an efficient draught; periodic medical examination; no food, drink or tobacco to be brought into the workroom; provision by the employer of adequate protective clothing; provision of suitable cloak-rooms, mess-rooms and washing accommodation and cleanliness of the workrooms, tools and apparatus.

An inspector under the Factory and Workshop Act may take samples to determine the presence of a lead compound whether inside a factory or in any place where it is suspected that a process involving the use of a lead compound is carried on. Notification to the Chief Inspector of Factories of lead poisoning contracted in any factory or workshop is to apply to lead poisoning contracted by any woman or young person in processes involving the use of lead compounds, whether carried on in factories or workshops or not. A penalty is imposed on any person employing a young person or woman in contravention of the Act in any other than a factory or workshop.

Orders have been issued by the Secretary of State (1) defining the meaning of the term lead compound and the method of ascertaining whether any compound is a " lead compound " for the purpose of the Act, (2) prescribing the medical examination of women and young persons employed in processes involving the use of lead compounds, (3) prescribing the cloak-room, mess-room, and washing accommodation to be provided in factories and workshops in which women or young persons are employed in processes involving the use of lead compounds.

Factory and Workshop Orders, 1922—This is a supplementary but highly important form of legislation under the Factory and Workshop Acts, 1891 and 1895 ; it took the form of special rules which, however, when established had the force of the Act.

A more convenient mode of procedure was established by the Act of 1901, under which the rules were issued as an order by the Secretary of State. The rules made under the Acts of 1891 and 1895 have been revised in the light of experience, and re-enacted as orders. They modify and extend the application of the various provisions of the 1901 and other Acts, and deal with such matters as hours and spells of work, meal times, employment during meal times, overtime, night work, particulars of work and wages, humidity in textile factories, home work, welfare work, but above all with dangerous and unhealthy industries.

These last orders extend over a long period, and summarise the results of many reports by the Inspectors of the Home Office and the results of many extensive inquiries, important committees, and special investigations. Amongst the more important matters which they regulate are the manufacture of lead and lead salts, and the application of these in various industries ; pottery, its manufacture and decoration, the crushing, grinding, etc., of refractory materials ; the generation, transformation, distribution or use of electricity ; the manufacture of india-rubber ; grinding of metals and racing of grindstones ; control of anthrax, etc. Their value is attested in many ways and plainly in the statistics of sickness and, though not to the same extent, in the statistics of accidents generally.

The Welfare Orders mostly deal with the immediate steps to be taken on the occurrence of accidents and incidentally with the prevention of sepsis as the result of minor accidents, and in the case of a considerable number of workers with the provision of an ambulance room, with its equipment and service and with the provision of ambulance service.

The National Insurance Act, 1911, and the various amending Acts which followed have an important bearing on industrial welfare. All persons of the age of 16 or upwards employed within the meaning of the Act shall be and any such persons who are not so employed but who possess the necessary qualifications may be insured and all persons so insured shall be entitled in the manner and subject to the conditions provided in the Act to the benefits conferred by the part of the Act relating to loss of health, and for the prevention and cure of sickness.

The ordinary rate of contribution is 10*d.* per week for men (5*d.* from the employer and 5*d.* from the workman) and 9*d.* for women (5*d.* from the employer and 4*d.* from the employee).

The benefits are medical, sickness, disablement and maternity. Medical benefit consists in the provision of medical attendance and treatment, including treatment and attendance for tuberculosis and the provision of proper and sufficient medicines, with such surgical appliances as are named in the regulations made by the Minister of Health.

An insured person who has joined a society is entitled to medical benefit immediately after he has joined. Sickness benefit means periodical payments during incapacity for work caused by some specific disease or by bodily or mental disablement of which notice has been given, commencing ordinarily on the fourth day of incapacity and continuing for a period of 26 weeks in all. Disablement benefit is a continuation of the periodical payments at a lower rate in respect of incapacity after the period of sickness has been exhausted. The ordinary rates for sickness benefit are 15*s.* a week for men, and 12*s.* for women, of disablement benefit 7*s.* 6*d.* for both. Sickness benefit does not begin until the insured person has been insured for 26 weeks, and 26 weekly contributions have been paid. Maternity benefit consists of the payment of 40*s.* on the confinement of the wife (or in the case of a posthumous child of the widow) of an insured man, or of a woman who is herself insured. If a married woman is insured she is entitled to two maternity benefits. Maternity benefit belongs to the woman whether her husband is insured or not. It is not payable, unless at the time of the confinement the person in respect of whose insurance the benefit is claimed has been insured at least 42 weeks.

The cost of treatment of tuberculosis in a sanatorium is defrayed by the Exchequer and by the local authority, and administered by the local authority under the Ministry of Health.

These are very substantial alleviations when the insured person is overtaken by illness.

The National Insurance Act also provides for a list of scheduled trades an unemployment fund created by contributions from the employer, the employee and the Treasury, provided the workman fulfils the statutory conditions. At the rate of contribution originally fixed for the insured workman, *viz.*, 2½*d.* per week, unemployment benefit was fixed ordinarily at 7*s.* a week, for a period of 15 weeks.[1]

Insurance is compulsory. The provisions are somewhat thorny. No benefit is paid under this part of the Act to a workman in receipt of any sickness or disablement benefit, or disablement allowance under Part 1 of this Act.

Under Part 1 sickness benefit is reduced or disappears for persons in receipt of compensation or damages under the Workmen's Compensation Act, and a society may oblige a member to take action to recover compensation or may take action for him. In the case of a discharged sailor, soldier, or airman, or any other person who is in receipt of a pension in respect of disablement in the highest degree for incapacity due to war service the rate of sickness benefit is reduced by 7*s.* 6*d.* and no disablement benefit is payable, but the reduction ceases to have effect as soon as the person has resumed employment at a remuneration which contributes substantially to his means of livelihood and has actually been at work for 26 weeks, while after he has been at work for 104 weeks, disablement benefit again becomes payable. No account is taken of any arrears during the period of reduction of benefit.

The Workmen's Compensation Act, 1906, provides machinery by which a workman incapacitated by accident sustained in the course of his employment, or in case of death, his representatives may claim compensation, also where (i) the certifying surgeon for the district in which the workman is employed certifies that he is suffering from one of a list of scheduled diseases, and is thereby disabled from earning full wages at the work at which he was employed; (ii) a workman is in pursuance of any special rules or regulations made under the Factory and Workshop Act, 1901, suspended from his usual employment on account of having contracted any such disease, or (iii) the death of a workman is caused by any such disease.

The diseases are anthrax, lead, mercury, phosphorus and arsenic poisoning or their sequelæ, and ankylostomiasis, contracted in the course of an industrial employment. The scale of compensation, and the administration of sums awarded are set forth in Schedules I and II. The Act also applies to ships as if a ship were a factory, the responsible person being in general the owner. In the case of the above diseases they are to be regarded as accidents. These notifications are transmitted to the district inspector, and are investigated by him with the assistance of the certifying surgeons, and in his turn he assists the certifying surgeons in what are at times his difficult duties.

MEDICAL WORK

Certifying factory surgeons must examine children or young persons as to their fitness for employment in the factory concerned.

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[1] This has been increased. See the Unemployment Insurance No. 2 Act, 1924. First Schedule, Part II.

When a "child" becomes a "young person" a fresh certificate of fitness must be obtained. The two examinations must have been a considerable protection to young persons, but will not now hold, as children are no longer liable to employment unless a second statutory examination is substituted. The certifying surgeon may qualify his certificate by conditions as to the work on which a child or young person is fit to be employed, and the occupier may not employ the young person or child except on those conditions. The occupier of a workshop may obtain if he thinks fit certificates of fitness of young persons under the age of sixteen (and children) for employment in his workshop, in like manner as if that workshop were a factory. Where it appears to the Secretary of State that by reason of special circumstances affecting any class of workshops, this course is necessary, he may by special order extend to that class of workshops, the prohibition of the employment of young persons under the age of sixteen years and children without a certificate of fitness.

No subsequent examination takes place, generally, notwithstanding the high incidence of disease in many employments, except in certain employments, subject to special risks, and particularly those attended with risk of lead poisoning. In these, periodic examinations are made at intervals of one to three months, as may appear necessary. These periodic examinations are made by the certifying surgeon or may be made in certain cases by a surgeon appointed by the Chief Inspector of Factories, either of whom has power to suspend from employment. The person suspended may not resume work in that class of employment without written sanction in the health register by the certifying surgeon (or appointed surgeon). Generally speaking, however, this kind of protection is very limited, unless as happens an employer appoints a medical officer to look after the health of his workpeople.

WHITLEY COUNCILS

A Committee with the Rt. Hon. J. H. Whitley, M.P., as Chairman was appointed to recommend, *inter alia*, means for securing that industrial conditions affecting the relations between employers and workmen shall be systematically reviewed by those concerned, with a view to improving conditions in the future. This Committee issued its first report in March, 1917, which was duly approved by employers' organisations and trade unions and adopted by the Government. It recommended that for industries organised as regards employers and employed, national industrial councils should be created, thoroughly representative of employers and employees, and that the organisation should be extended by the formation of district industrial councils and works committees formed on a similar basis, but subordinate to the national councils, it being anticipated that the Government would find the national councils convenient bodies to consult on the interests of their respective industries. Memorandum No. 4 (revised) issued by the Ministry of Labour in 1920, deals with the functions of industrial councils, and works committees.

Amongst the suggested functions of joint industrial councils are the improvement of the health conditions obtaining in the industry and the provision of special treatment where necessary for workers in the industry. The functions of district councils suggested are, *inter alia,* to consider any matters that may be referred to them by the National Joint Industrial Council, and by works committees and to take executive action within their district in connection with decisions arrived at and matters deputed by them to it. The matters of interest include the general district practice relating to welfare work and the improvement of health conditions. The functions of works committees suggested included questions of physical welfare (provision of meals, drinking water, heating, lighting, and sanitation, accidents, safety appliances, first aid, ambulance, etc.). Model schemes are set forth in the memorandum. The functions of works committees vary greatly, but it is suggested that the safety committees and welfare committees will conveniently be subcommittees of the works committees.

WELFARE

Welfare work in industrial undertakings may be divided into two parts, according as it is more concerned with the general health of the workers or with first-aid arrangements, although in practice there may be no absolute distinction. It is with the former class of work that the welfare supervisor has to deal. He or she is appointed by the management; the number of women at present exceeds that of men supervisors. There was at first no recognised qualification, and the supervisor was presumably appointed by reason of special qualifications, such as a considerable knowledge of factory life, tact, ability to work with managers and foremen and to gain the confidence of the workers with whom they have to deal; much more severe requirements are now demanded of them. They should be educated, and have business experience, be able to keep records of sickness, manage clubs, canteens, and arrange recreations, watch over the health of employees, engage them when requested to do so, know about their home conditions, and, in fact, take an interest in everything which ministers to the comfort and well-being of the workers, besides taking their share in the observation of welfare orders and first aid.

The second branch of welfare work, *viz.*, that more allied to first-aid and "safety first" work, is represented in the Welfare Orders issued by the Home Office for a number of industries, under the Police, Factories, etc., Act, 1916.

It is regarded of prime importance that first-aid boxes should only contain the essentials mentioned in various orders, dressings, etc., required for the early treatment of the injuries likely to be met with in the trade concerned. A list of welfare orders is given in the Factory and Workshops Orders, 1922. There is only one of general application, *viz.*, 1917, No. 1068, which requires that every factory and workshop shall have an adequate supply of wholesome drinking water, conveniently situated, with suitable appliances, clearly marked as "Drinking Water."

In the sense of subserving health, most welfare and safety requirements are contained in the orders relating to dangerous industries. The majority of the welfare orders are concerned with the application of first aid when accidents or injuries have been actually sustained. In the industries dealt with, the orders prescribe first-aid boxes, for every 150 or part of 150 workers, and when the numbers reach 500 an ambulance room with skilled medical or nursing attendance or both, and preferably with a motor ambulance,[1] or in lieu immediate access to an ambulance service. First-aid boxes should be increased in number where accidents are numerous, or workshops scattered. They should be in charge of a workman who has received special training in first-aid instruction. It is also desirable that more than one of the workmen should receive instruction in first aid. He should always be available, and it will be his duty to keep a record of any accident with the cause and implement, the hour and date of the accident, and the hour and date at which first aid were rendered.

SAFETY

The number of accidents occurring in industrial undertakings every year is enough to stimulate the imagination to produce an effort to reduce it, especially as many of them are preventible with reasonable care. During 1919 the number of accidents reported to the Factory Department of the Home Office was 124,638, of which 40,056 were due to machinery and 84,582 were non-machinery cases. In 1920 the number was 138,702, of which 1,404 were fatal. These numbers are less than those for previous years, the reduction in 1921 being attributed to inactivity in industry.

At a conference organised by the Home Office and the British Industrial "Safety First" Association in September, 1920, the appointment of a Safety Inspector at factories and the establishment of a Safety Committee composed of representatives of the management and of workers were recommended. This Committee would receive reports on all the accidents prepared by the Safety Inspector and hear witnesses and visit the scene of the accident and institute further inquiries themselves, and most important of all, they should publish an account of each accident, of the causes which led to it, and of the result of their inquiries.

A second duty which should be undertaken at regular intervals, is the inspection, together with the departmental manager or foreman, of the different departments of the works and the preparation of recommendations on all matters pertaining to safety. Yet another duty which should be undertaken is the consideration of safer methods of working and suggestions to this end should be encouraged.[1]

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[1] For the description of ambulance provision and their equipment, reference should be made to the memorandum issued by the Home Office in 1919 on First Aid and Ambulance in Factories and Workshops. In a memorandum, also issued in 1919, Welfare and Welfare Supervision in Factories and Workshops, the general subject of welfare is discussed.

The Shops Act, 1912, is administered by the local authority. This is a consolidating Act. Its main object is to regulate the hours of employment, meal times and hours, closing hours, weekly half-holidays, other holidays and half-holidays. On at least one week-day in each week a shop assistant shall not be employed about the business of a shop after half-past one o'clock in the afternoon. The occupier of a shop shall fix and shall specify in a notice in the prescribed form which must be affixed in the shops in such manner and at such time as may be prescribed, the day of the week on which his shop assistants are not employed after half-past one o'clock, and may fix different days for different assistants. No person must be employed for more than six hours without an interval of at least twenty minutes. Where the hours of employment include from 11.30 a.m. to 2.30 p.m., an interval of not less than three-quarters of an hour must be allowed for dinner between these hours, and if they include from 4 p.m. to 7 p.m., not less than half-an-hour for tea. Seats in a certain proportion are to be provided for female assistants (but no provision is made that they must be used or under what conditions). Every shop with certain specified exceptions shall be closed for the serving of customers not later than one o'clock in the afternoon on one week-day in every week. "The local authority may by order fix the day on which a shop is to be closed, and any such order may either fix the same day for all shops and may fix :—

(*a*) Different days for different classes of shops, or
(*b*) Different days for different parts of the district,
(*c*) Different days for different periods of the year."

The Act is mainly concerned along with the Shops Regulations, 1912, with the machinery by which the views of different trades and areas may be ascertained by the local authority as regards closing hours and weekly half-holidays and orders made accordingly and confirmed by the Home Secretary, a result not always easily attained. Young persons are not to be employed in or about a shop for a longer period than seventy-four hours, including meal times, in any one week. The hours are not prescribed for other persons and the hour of closing need not coincide with the hour at which the shop assistant is free from occupation.

The Shops Act, 1913, amending the Shops Act, 1912, in its application to premises for the sale of refreshments, provides an alternative scheme for the holidays of assistants.

Inspectors under these Acts are appointed by the local authority and in some instances are members of the health staff. Proceedings for contravention are taken as in Section 146 of the Factory and

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[1] The Home Office has issued a pamphlet on the duties of safety committees.

Workshop Act, 1901. Inspectors appointed by the local authority under this Act are to have in relation to shops all the powers conferred in relation to factories and workshops on inspectors by Section 119 of the Factory and Workshop Act, 1901.

Alkali, etc., Works Regulation Acts, 1881 and 1892. (See p. 63.) The Amending Act of 1892 extended the operation of the principal Act to Venetian red works, arsenic works, and some other trades. The Alkali, etc., Works Regulation Act, 1906, is a consolidating Act. It is, generally, better to leave the alkali inspector to deal with nuisances arising from the works which come under the Act, though the escapes of sulphuric acid into the atmosphere, or of noxious matters into the sewer, may, or did formerly, compel the public health authority to take proceedings. In that case the assistance of the alkali inspector would be relied upon.

Cemeteries and Burial Grounds—The evils resulting from intramural burials and from overcrowding of burial grounds attracted much attention towards the middle of the last century. In 1834 Sir Edwin Chadwick reported on the subject. The overcrowding of metropolitan churchyards gradually led, at about this time, to the formation of cemetery companies, and it was with a view to providing a code of rules, to be applied in cases in which private companies made application for the necessary powers, that the Cemeteries Clauses Act of 1847 was passed. The Public Health Act of 1848 forbade throughout the country generally interments underneath, or within the walls of, any church built after that year.

The Burial Act, 1852—This, the first of the Burial Acts, provided that no new burial ground or cemetery within two miles of the metropolis should be brought into use without the approval of the Secretary of State, and it authorised the making of Orders in Council for the discontinuance of burials in any part of the metropolis subject to certain exceptions; it also provided for the constitution of burial boards for parochial areas. The Act originally applied only to the metropolis, but in 1853 its operation was extended to the whole of England and Wales. In 1855 an amending Act provided for the appointment of burial boards for united parishes, and prohibited a burial ground being within 100 yards of a dwelling-house without consent. The Act of 1852 empowered the Secretary of State to make regulations as to burial grounds, for the protection of the public health and the maintenance of public decency, and from time to time such regulations have been made.

The Public Health Interments Act, 1879, extended the provisions of the Public Health Act, 1875, relating to mortuaries, to cemeteries, and empowered sanitary authorities to provide a cemetery, imposing upon them the obligation to do so if required by the Local Government Board. This Act incorporated the provisions of the

Cemeteries Clauses Act of 1847, in which power is given to burial boards to obtain land by compulsory purchase for the construction, etc., of new cemeteries.

Sanitary authorities, by the application to cemeteries of Section 141 of the Act of 1875, were, moreover, empowered to make by-laws with regard to such places.

The Disused Burial Grounds Act, 1884, provided that no buildings should be erected on any disused burial ground to which the Act applied, except for the purpose of enlarging a place of worship, and the scope of this provision was extended by the Open Spaces Act of 1887, which amended the definitions of "disused burial ground" and "building." The last-named Act also gave facilities for the acquirement and maintenance as open spaces of disused burial grounds, extending to other parts of the country, powers already existing in London in virtue of the Metropolitan Open Spaces Acts of 1877 and 1881.

It not infrequently happens that in clearing sites in large towns coffins and bodies are met with, when the human remains will require to be re-coffined and removed for re-interment. Should these be in consecrated ground, a faculty must be obtained from the Bishop of the diocese; in other instances a licence from the Secretary of State. These operations are not unlikely to be embodied in a local Act, in which case either the Secretary of State or the Bishop may make it a condition that the removal has been to the satisfaction of the medical officer of health.

In a **Memorandum on the Sanitary Requirements of Cemeteries,** issued by the Local Government Board in 1888, it was pointed out that the dangers to the public health, to which places of burial may give rise, are of two kinds—there is risk of contamination (1) of air, by gaseous and volatile substances, and (2) of drinking water, by liquid products of decomposition. As regards the former, the risk must be obviated, according to the Memorandum, by limiting the number of decomposing bodies, causing a sufficient depth to intervene between the corpses and the surface, choosing suitable soils, and providing for their adequate drainage. Moreover, the place of burial should be "in an open situation and at a sufficient distance from dwellings." As regards the latter risk, suitability of soil and efficient means of drainage are of importance, and the burial ground should be "at a sufficient distance from subterranean sources of water supply."

The sanitary requirements for a cemetery are summed up under four heads:—

(1) *Suitable soil and a proper elevation of site*—The soil should be of an open porous nature with numerous close interstices. It should be easily worked, and free from water or hard rock to a depth of at

least 8 feet; if not naturally free from water, it should be adequately drained, and for that purpose should be sufficiently elevated above the drainage level of the locality. Loam and sand with a sufficient quantity of vegetable mould are the best, clay and loose stones the worst forms of soil.

(2) *Suitable position*, especially with respect to houses and sources of water supply. Public convenience requires that the cemetery shall not be too far distant from the population for which it is intended; a due regard to public health requires that it shall not be dangerously near; a distance of 100 yards from the nearest dwelling-house, except with the consent of the owners and occupiers, is required. It is clear that the drainage of a cemetery should not be allowed to enter a stream used for the supply of water for domestic purposes. The Memorandum points out that it does not appear "that the risk to which wells are exposed from the proximity of a properly managed cemetery is in ordinary cases great. A leaky cesspool is a far greater source of danger than a grave. The solid and liquid excretions voided by a human being in the course of a single year amount to several times the weight of his body."

(3) *Sufficiency of space*—The sizes of grave spaces are dealt with in the Home Office regulations; fourteen years are deemed necessary for the decomposition of the body of an adult, eight for that of a child. As regards population, an allowance of a quarter of an acre per thousand inhabitants is usually estimated as being the minimum for a period of fourteen years.

(4) *Proper regulation and management*—This matter is made a subject of consideration in the model by-laws and in the regulations issued by the Home Secretary.

Within recent years a system of disposing of dead bodies has been advocated, which if adopted would involve considerable or entire reorganisation of existing methods of burial. "Surface burial" is usually understood to imply the employment of perishable coffins placed near the surface; by this means, more rapid dissolution may be anticipated than occurs when resistant coffins are used and when these are placed at some depth. Sir Seymour Haden, as the result of experiments which he made with the bodies of animals, found that a period of "something more than four years (depending mainly on the size of the animal buried) was necessary for complete dissolution; and, speaking roundly, that for every foot of depth below the surface a year or thereabouts was necessary; for a depth of 3 feet, three years; of 2 feet, two years; and of 1 foot, one year. In a word, that dissolution was rapid in proportion as the grave was shallow and the soil porous." He pointed out that, if the system of burial near the surface in perishable coffins were adopted, the land after the lapse of a few years would again be liberated for purposes of hygiene or of utility. He further referred to the experience of the Commission appointed by the Prussian Government to inquire into the condition of the dead in the battlefields of the Vosges. The Commission found that, after the lapse of nine months or thereabouts, "in cases in which as many as 800 dead bodies, in the hurry incident to rapid military movements, had been thrust into one shallow excavation," the bodies had already disappeared, their bones and accoutrements alone being left; but to this unexpected disappearance there was a remarkable exception—the bodies of officers buried in their mackintoshes (which thus represented more or less the condition of bodies buried in coffins) had not disappeared. Coffins made of paper pulp or millboard about one-eighth of an inch in thickness, on a framework of wood, have been recently introduced, but they have not hitherto been much used, and experience is wanting as to the applicability of surface burial on a large scale. (See Report by C. W. F. Young, Appendix III., Ann. Rep. Med. Off. County of London, 1899.)

Cremation—This method of dealing with dead bodies has been widely adopted at various times in the world's history. In recent years there has been a steady growth of opinion in favour of the practice among civilised nations. In 1883 a judgment was given by Sir James Stephen to the effect that cremation was a legal proceeding if no nuisance was caused, and in 1885 the Cremation Society, which had been established in 1874, carried out its first cremation at Woking. Since then crematoria have also been established at fourteen other places. The number of cremations in Great Britain in 1922 was 2,009; in the last seven years the rate of increase has been about 75 cremations each year. The number of bodies so dealt with, however, remains at the low proportion of about 0·4 per cent. of all deaths. There has been a steady extension of the practice of cremation; the number of crematoria abroad in 1898 was 70 and in 1922 194, mostly in the United States, Germany, Italy and Switzerland. In the modern crematorium an ordinary body is reduced to some 3 lbs. of ash in about two hours. The advantages of cremation from the point of view of the public health are obvious; in particular it has been urged that it at once destroys the germs of infectious disease.

Several objections have been raised to the practice. Certain religious persuasions, notably the Roman Catholic and Jewish, are opposed to cremation; sentiment has also been opposed to it in the past, but the force of this class of opposition appears to be waning. The only hostile criticism which really demands serious notice is the contention that, inasmuch as it would be impossible to exhume for purposes of chemical examination, cases of poisoning would be less likely to be detected, and that this might lead to increase of crime. Under existing conditions exhumation is very rarely resorted to, but it is urged that the fact that it may be practised in a particular case acts as a deterring influence. An improved system of death certification, and the retention in particular instances of the stomach and of a portion of one of the viscera, have been suggested as being practical means of obviating all risk in this connection. It is quite clear that much more can be done, in the direction of preventing crime, by improving the certification system, than is effected by its being known that the body of a person who has been poisoned may at a later date be exhumed for the purposes of examination. Moreover, regulations made by the Home Office, in 1903, under Section 7 of the Cremation Act, 1902, require such precautions prior to cremation, as ought to be effectual in preventing the body of any person who has been poisoned, from being cremated, and, in fact, probably, in many cases, act as a deterrent to cremation. The relatively high cost of this method of disposal is another difficulty.

BY-LAWS AND REGULATIONS

The Local Government Board first issued nine sets of model by-laws in July, 1877. In July, 1882, sixteen principal series had been issued, and further sets have since been framed. The subjects to which these groups of model by-laws relate are as follows :—

I. Private Scavenging.
II. *Prevention of nuisances.*
III. Common Lodging-houses.
IV. *New Streets and Buildings.*
V. Markets.
VI. *Private Slaughter-houses.*
VII. Hackney carriages.
VIII. *Public bathing.*
IX. Public baths, washhouses and open bathing places.
X. *Pleasure grounds.*
XI. *Horses, etc., standing for hire.*
XII. *Pleasure boats.*
XIII. Houses let in lodgings or occupied by members of more than one family.
XIV. Cemeteries.
XV. Mortuaries.
XVI. *Offensive trades.*
XVII. Hop-pickers and fruit-pickers.
XVIII. Tents and vans.
See also under the Public Health Acts Amendment Act, 1890.

There are a few other subject-matters concerning which by-laws can be made, but with regard to which model by-laws have not been issued. Such are public slaughter-houses, public conveyances, public recreation grounds, streets and buildings (the by-law making powers given by Section 157 of the 1875 Act being extended by Section 23 of the Act of 1890), removal of offensive material through the streets, and removal of house refuse (powers to control these matters being also given under the Act of 1890). Local authorities are empowered to make certain regulations, notably under the Dairies, Cowsheds, and Milk Shops Orders, also with regard to public sanitary conveniences, cabmen's shelters, and allotments. There is further a power to make regulations (to be approved by the Local Government Board) for removing to hospital infected persons brought within a district by ships. Some by-laws (those indicated in italics in the list given above) can only be made by urban authorities. It may, moreover, be noted that by-laws as to common lodging-houses and slaughter-houses *must* be made by urban authorities; as regards the other matters, the powers are permissive, and no obligation is placed on the authority to make the by-laws.

Section 182 of the Public Health Act, 1875, contains the words:—"No by-law made under this Act by a local authority shall be of any effect if repugnant to the laws of England or to the provisions of this Act." In order not to be repugnant to the general law, a by-law must be reasonable and certain and determinate. The Local Government Board, in a circular letter of July, 1877, pointed out, as regards reasonableness, that "The exercise of the power which the Legislature has confided to Sanitary Authorities must frequently bring them into contact with important interests. Within certain limits they may regulate the conduct of persons employed in certain specified callings. They may impose restrictions upon the enjoyment of individual rights and privileges. Trade and property may, under certain conditions, be affected by their action. These considerations point to the necessity for prudence and deliberation in the choice of by-laws, so that the duties and restraints which they create may not interfere oppressively with individual freedom of action." Two instances of judgments given in the courts may be cited; thus a by-law prohibiting the keeping of swine within fifty feet of any dwelling-house, within a rural district, was held to be unreasonable; on the other hand, in an urban district a by-law prohibiting the keeping of swine within 100 feet of a dwelling-house has been held to be reasonable.

As regards the need for making by-laws certain and determinate, the Board, in the circular letter above referred to, point out that assumption by the Sanitary Authority of "power of suspending the operation of particular provisions in individual cases is open to much objection." Again, the Board disapproves of inserting, in place of "necessary details," "vague conditions which render compliance with the by-laws dependent upon the approval by the Sanitary Authority or their officers of the mode of proceeding in each case." The letter states that "The Board think that every person, who by neglect of the rules which a by-law is intended to prescribe may be rendered liable to a penalty, is entitled to demand from those who impose such rules a clear statement of the course of action which must be followed or avoided."

As regards the need for a by-law not being repugnant to the provisions of the Act under which it is made, the Board point out that "authorities cannot legally assume the power of making by-laws for carrying out the general objects of the Act. It follows, therefore, that every by-law must be strictly limited with reference to the terms of the specific enactment from which its force is derived. Any attempt by the strained construction of any such enactment to extend the range of a by-law should especially be avoided."

Section 182 of the Act of 1875 provides that by-laws shall be under the common seal of the local authority, and Section 185 requires that they shall be printed and exhibited and open to inspection. By-laws are of no validity until they have been confirmed by the confirming authority; in this respect, and also by reason of the fact that infringement of the provisions of a by-law entails liability, as a rule, to the imposition of a penalty, they differ from "regulations." Sometimes regulations, however, require confirmation, and in particular instances regulations contain a penalty clause, so that the distinctions mentioned are not of invariable application.

The following is a brief summary of the provisions contained in the model by-laws :—

I. **Private Scavenging**—Under Section 44 of the Act of 1875 it is provided that "where the local authority do not themselves undertake or contract for

> "The cleansing of footways and pavements adjoining any premises ;
>
> "The removal of house refuse from any premises ;
>
> "The cleansing of earth-closets, privies, ashpits, and cesspools belonging to any premises ;

"they may make by-laws imposing the duty of such cleansing or removal, at such intervals as they think fit, on the occupier of any such premises."

The by-laws are only applicable in districts in which the local authority do not themselves perform the work of scavenging. Under Section 42 of the Act a local authority may, and when required by order of the Local Government Board shall, undertake such duties.

Where this is not done it is usual for by-laws to impose upon occupiers of premises the duty of providing for the daily cleansing (Sundays excepted) of footways and pavements ; for the weekly removal of house refuse ; for the cleansing once at least in every three months of earth-closets with fixed receptacles, and once at least in every week of earth-closets with movable receptacles ; for the cleansing at least once a week of privies, whether the receptacles are fixed or movable, and of ashpits, whether used in connection with privies or merely as receptacles for ashes, dust, and dry refuse ; and for the cleansing once at least in every three months of cesspools.

II. **Prevention of Nuisances**—By-laws under this head provide for the clearing away of snow on footways ; for the use of suitable vessels or receptacles (with sufficient coverings) for the removal of filth ; for the cleansing of privies, etc., during certain hours (those usually specified are between the hours of 6 and half-past 8 in the forenoon in the summer months, and the hours of 7 and half-past 9 in the forenoon in the winter months); for preventing night soil, manure, etc., being deposited for more than twenty-four hours within a specified distance (usually 100 yards) of any premises used for human habitation, or as a school, place of public worship or public assembly, or place of business; and for the prevention of nuisance from the unloading or depositing, or conveyance through the streets, of any kind of "filth emitting a stench." These by-laws also deal with the keeping of swine in proximity to dwellings, with the keeping of cattle, or the deposit of the dung of cattle in such a manner as to pollute any supply of water for domestic use, with the provision, construction and cleansing of dung receptacles, and with the cleansing of stables.

III. **Common Lodging-houses**—These by-laws contain provisions—(1) "For fixing and from time to time varying the number of lodgers who may be received into a common lodging-house, and for the separation of the sexes therein." The practice generally adopted is to prescribe the maximum number of lodgers to be received in each room (300 cubic feet of space is often fixed as the minimum allowance in rooms used by night only). As a rule, no person over ten years of age is allowed to occupy any room used as a sleeping apartment by persons of the opposite sex; but the use of a common sleeping apartment by married couples has been hitherto generally permitted, provided each bed is effectually screened, by means of a partition of wood or other solid material extending upwards to a sufficient height, and downwards to a distance of not more than 6 inches above the level of the floor.

It is usual to provide that no bed in a room used as a sleeping apartment by persons of the male sex, above the age of ten years, shall be occupied at any one time by more than one such person.

(2) "For promoting cleanliness and ventilation in such houses." Under this head by-laws are usually made dealing with the sweeping of floors and staircases, the cleansing of windows and fixtures and of yards, the cleansing of beds and bedding, the keeping in good order of water-closets, earth-closets and ashpits, the provision of lavatory accommodation, the removal of filth and refuse from rooms, the opening of windows at stated times, and the keeping in order of the means of ventilation.

(3) "For the giving of notices, and the taking of precautions in the case of any infectious disease." Immediate notice is required to be given of the occurrence of illness of an infectious character, prompt removal of any lodger affected with such illness is provided for, and requirements as to cleansing and disinfecting rooms, as to ceasing, if required by the medical officer of health, to receive lodgers in par-

ticular rooms, and as to complying with all instructions given by that officer with regard to the proper cleansing and disinfection of rooms and articles contained therein, are usually made.

(4) " Generally, for the well ordering of such houses." In addition to the requirements already specified, by-laws are often made requiring that kitchens shall not be used as sleeping-rooms, that there shall be an interval of at least eight hours between successive occupations of the same bed, that notices specifying the maximum number of lodgers authorised to be received in any particular room, and that copies of the by-laws, shall be, if required, fixed in suitable and conspicuous positions.

IV. **New Streets and Buildings**—By-laws under this heading have concern with the level, width, construction and sewerage of new streets ; the structure of walls, foundations, roofs and chimneys, for securing stability and the prevention of fires, and for purposes of health ; the sufficiency of the space about buildings to secure free circulation of air, and the adequate ventilation of buildings ; with the drainage of buildings, with water-closets, earth-closets, privies, ashpits, and cesspools in connection with buildings, and with the closing of buildings unfit for human habitation. This important series of by-laws has already been referred to in some detail in Chapter VI.

V. **Markets**—The questions of public health interest mainly involved in connection with markets are those relating to prevention of nuisance arising from the keeping of animals, to inspection of slaughter-houses, and to prevention of the sale, or exposure for sale, of unwholesome provisions in the market-place.

VI. **Slaughter-houses**—By-laws under this heading prescribe the mode of application for licences and for registration. Slaughter-houses in existence prior to the time when the provisions in the Public Health Act relating to such premises were first applied to the district, and which have continued to be used as slaughter-houses ever since, do not require a licence, but they must be registered. (See p. 690.) The by-laws provide for access being afforded for purposes of inspection, for animals being supplied with water during confinement, for the use in the process of slaughtering of such instruments and appliances and the adoption of such methods as will prevent unnecessary suffering ; for the maintenance of drainage, water-supply, and means of ventilation in efficient order ; for keeping the slaughter-house in good repair ; for lime-washing at stated periods ; and for cleansing being carried out within a stated number of hours after slaughtering or dressing.

Further, provision may be made that no dog shall be kept in the slaughter-house, the object of this prohibition being the prevention of the spread of parasitic disease, and particularly of hydatid disease

(*Tænia echinococcus* being of common occurrence in dogs). Again, it is usual to prohibit the keeping in any slaughter-house of an animal the flesh of which may be used for human food, unless the animal is so kept in preparation for slaughter upon the premises. Finally, the by-laws may provide for the removal of hides, offal, etc., within a stated time after the completion of slaughtering, for the collection and removal of blood in proper receptacles or vessels, and for the cleansing of such vessels.

These by-laws, it will be noted, do not refer to questions of structure, but the considerations to which regard may be paid, in the case of premises subject to the discretionary power of licensing on the part of the Sanitary Authority, have been summarised in a Local Government Board Memorandum, as follows :—

" (1) The premises to be erected, or to be used and occupied as a slaughter-house, should not be within 100 feet of any dwelling-house, and the site should be such as to admit of free ventilation, by direct communication with the external air on two sides at least of the slaughter-house.

(2) Lairs for cattle in connection with the slaughter-house should not be within 100 feet of a dwelling-house.

(3) The slaughter-house should not in any part be below the surface of the adjoining ground.

(4) The approach to the slaughter-house should not be on an incline of more than one in four, and should not be through any dwelling-house or shop.

(5) No room or loft should be constructed over the slaughter-house.

(6) The slaughter-house should be provided with an adequate tank, or other proper receptacle for water, so placed that the bottom shall not be less than 6 feet above the level of the floor of the slaughter-house.

(7) The slaughter-house should be provided with proper ventilation.

(8) The slaughter-house should be well paved with asphalt or concrete, and laid with a proper slope and channel towards a gully, which should be properly trapped and covered with a grating, the bars of which should not be more than three-eighths of an inch apart. Provision should also be made for the effectual drainage of the slaughter-house.

(9) The surface of the walls in the interior of the slaughter-house should be covered with hard, smooth, impervious material to a sufficient height.

(10) No water-closet, privy, or cesspool should be constructed within the slaughter-house. There should be no direct communication between the slaughter-house and any stable, water-closet, privy, or cesspool.

(11) Every lair for cattle in connection with the slaughter-house should be properly paved, drained, and ventilated. No habitable room should be constructed over any lair."

VII. **Houses Let in Lodgings or Occupied by Members of more than one Family**—Under Section 90 of the Act of 1875 the Local Government Board could empower local authorities to make by-laws, for fixing the number of persons who may occupy a house or part of a house let in lodgings, for the separation of the sexes therein, for the registration and for the inspection of such houses, for enforcing drainage, etc., and cleanliness, for lime-washing, paving yards, etc., and for giving notice and taking precautions in case of any infectious disease in such houses. The need for the enactment being declared to be in force in any particular district, by the Board, was removed by Section 8 of the Housing of the Working Classes Act, 1885, so that local authorities were empowered, from that date, to make by-laws without any preliminary declaration.

In London the obligation of making such by-laws was placed upon Sanitary Authorities by the Public Health (London) Act, 1891. When the practice of letting houses for occupation by several families first became established in London it was seen to be fraught with an element of considerable danger. It appears, however, that house-to-house visitation in poor neighbourhoods, undertaken at times of cholera prevalence, specially served to emphasise the importance of inspecting houses of the poorer sort occupied by more than one family. Already, in "the sixties," power had been obtained under a special Act for dealing with the matter in the City of London. The Sanitary Act of 1866 practically gave the right of making by-laws with regard to such houses to any authority choosing to make application for it. The Housing of the Working Classes Commissioners, in 1884, were greatly impressed with the usefulness of the by-laws, which had been enforced at that time in a few districts.

The early tenement-house regulations referred to a variety of matters which are now in many instances included within the scope of special by-laws relating to drainage, collection of refuse, yard paving, the keeping of animals, etc., and applying not only to tenement houses, but to houses generally. Moreover, the power given in 1866 to make by-laws as to giving notice of infectious disease, occurring in tenemented houses, has now by the general application of the system of notification been rendered practically unnecessary. Thus, many of the rights originally conferred on authorities, and in some instances exercised by them, with regard to houses let in lodgings are now applicable to houses of all kinds.

There still remain, however, certain powers which can, with advantage, be specially applied to this class of houses. The most important of these are those relating to enforcement of periodical cleansing, lime-whiting, etc., and to the control of overcrowding. Further, under special by-laws, rights of entry "at all times" can be obtained; this is a matter of great importance in connection with overcrowded tenemented houses. Proof of the existence of overcrowding can, as a rule, only be obtained by inspection at night time; such inspection should, of course, only be undertaken under exceptional circumstances, and with exercise of all due precautions. As a matter of fact, it has been found that when once it is understood that the power may be occasionally used overcrowding ceases to exist, and this in houses and localities in which the overcrowding difficulty has been previously found to be an insurmountable one. The reason no doubt is that under by-laws there is liability to penalty upon proof of the overcrowding being forthcoming, whereas, in the ordinary nuisance procedure, all that can be done is to obtain an order requiring its abatement. Under the latter system tenants have in practice been disturbed to little or no purpose; the rooms evacuated are again, as a rule, let in such a way as to reproduce the overcrowding, and the outgoing tenants often merely pass from one to another set of overcrowded rooms. The power of applying directly for penalty, taken in conjunction with that of obtaining proof of the existence of overcrowding, disposes of these difficulties at once; indeed, the mere moral effect of the knowledge that these powers are likely to be exercised has been found to produce a greater impression than the abatement notices of a long series of years had been able to effect.

In the Model By-laws "landlord" is defined as "the person (whatever may be the nature or extent of his interest in the premises) by whom, or on whose behalf, the house or part of a house is let in lodgings, or for occupation by members of more than one family, or who for the time being receives, or is entitled to receive, the profits arising from such letting." The by-laws impose upon the landlord the responsibility for structural details; but in cases where a lodger has exclusive use of a particular appliance such lodger is made liable for its maintenance in a wholesome condition. As regards overcrowding, it is usual to prohibit both landlord and lodger from knowingly causing or suffering the condition to exist.

The Model By-laws contain a clause to the effect that a lodging-house shall be exempt from the operation of the by-laws :—

(*a*) Where the rent or charge payable by each lodger, and exclusive of any charge for the use by such lodger of any furniture, is at the rate of —— per week or upwards.

(*b*) Where the rent or charge payable by each lodger, and inclusive of any charge for the use by such lodger of any furniture, is at the rate of —— per week or upwards.

The limits of rent prescribed are, of course, intended to be varied according to the circumstances of the particular locality. The Local

Government Board pointed out in a Memorandum of July, 1899, that it is desirable to exempt from the operation of the by-laws " lodging-houses as to which it may reasonably be inferred that such supervision as elsewhere a local authority alone can efficiently exercise will, in fact, be exercised by the lodgers themselves." Difficulty has been experienced in some instances in connection with " exemption limits " by reason of the fact that the rentals fixed have been found to exclude houses which might with great advantage have been regulated.

The standards of air space laid down in the model by-laws are as follows :—

For rooms used by night only—
- 300 cubic feet for each person of an age exceeding 10 years.
- 150 cubic feet for each person of an age not exceeding 10 years.

For rooms not used exclusively at night—
- 400 cubic feet for each person of an age exceeding 10 years.
- 200 cubic feet for each person of an age not exceeding 10 years.

The Memorandum already referred to states that, if it should in future be found " practicable to enforce an increased allowance of free air space, the Board will gladly facilitate the confirmation of new by-laws for that purpose."

The Statute gives power for a by-law to be made as regards " separation of the sexes." The model series makes no mention of the subject, but a by-law has, in particular instances, been confirmed to the effect that " a lodger in a lodging-house shall not suffer any person above the age of 12 years to occupy as a sleeping apartment any room let to such lodger, if the room is occupied by more than one person above that age and of the opposite sex."

As regards periodical cleansing and lime-washing, the model by-law prescribes that " in the first week of the month of —— in every year, ... the landlord shall cause every part of the premises to be cleansed," and further that " he shall cause the internal walls and ceilings to be washed with hot limewash," save in particular instances where the surface is covered with paint, or other material to which the application of limewash would be "unsuitable or inexpedient," and where such surface is thoroughly cleansed, and the paint or other covering, if necessary, renewed.

In addition to those already referred to, the model series contains requirements as to the landlord's furnishing particulars concerning the mode of occupation of the house ; as to rights of entry and obstruction of officers ; as to water-closets, etc., and their maintenance in a cleanly condition ; as to the cleansing of yards, floors, windows, staircases, cisterns, etc., and the removal of filth and rubbish ; as to the keeping of animals; as to ventilation; and as to precautions being taken with regard to infectious disease.

Section 26 (1) of the Housing and Town Planning Act, 1919, runs thus: "The power of making and enforcing by-laws under Section 90 of the Public Health Act, 1875, and Section 94, of the Public Health (London) Act, 1891, shall in the case of houses intended or used for occupation by the working classes be deemed to include the making and enforcing of by-laws":—

(*a*) For Fixing and from time to time varying the number of persons who may occupy a house or part of a house which is let in lodgings or occupied by members of more than one family, and for separation of the sexes therein.

(*b*) For the registration and inspection of such houses.

(*c*) For enforcing drainage and promoting cleanliness of such houses.

(*d*) For requiring provision adequate for the use of and readily accessible to each family of—

(1) closet accommodation,
(2) water supply and washing accommodation,
(3) accommodation for the storage, preparation, and cooking of food,

and where necessary for securing separate accommodation as aforesaid for every part of each house which is occupied as a separate dwelling.

(*e*) For the keeping in repair and adequate lighting of any common staircase in such houses.

(*f*) For securing stability, and the prevention of safety from fire.

(*g*) For the cleansing and redecoration of the premises at stated times and for the paving of the courts and courtyards.

(*h*) For the provision of handrails, where necessary, for all staircases of such houses.

(*i*) For securing the adequate lighting of every room in such houses.

Section 14 of the Housing, etc., Act, 1923, adds as another object of the by-laws:—

(*j*) For the taking of precautions in the case of any infectious disease.

Any such by-laws may prohibit the letting for occupation by members of more than one family of any such house unless the same are complied with.

It will be seen that the scope of the Model By-laws is considerably extended, and the Ministry of Health has therefore issued a set of Model By-laws to carry out the above purposes.

No provision for limit of rent is made or intended, although the by-laws are only applicable to houses intended or used for occupation by the working classes. The lower limit of space in a room used wholly or partly as a sleeping apartment is fixed at 360 cubic feet of free air space for each person of an age exceeding ten years, and 250 cubic feet for each person of an age not exceeding ten years.

Provision is made for the adequate lighting of every habitable room and where practicable of every staircase by natural light, in any case by artificial light, also for the keeping of common staircases in repair. Every owner must provide adequate for the use of, and readily accessible to, each family by whom any part of the house is occupied :—

(*a*) Water-closet accommodation.

(*b*) A supply of water for domestic use.

(*c*) Accommodation for washing clothes.

(*d*) Accommodation for the storage of food in a reasonably cool position with proper ventilation from the external air whenever practicable, and with protection from dust and flies.

(*e*) Accommodation for the preparation and cooking of food, and where necessary separate accommodation as aforesaid for every part of the house which is occupied as a separate dwelling.

A lodging-house must be maintained in a condition of adequate stability. In the erection of a new building intended to be used as a lodging-house, the structural conditions are required to safeguard it from fire. Every flight of stairs, passage, and other means of escape in the house must be kept by the occupier free from obstruction, and every door fitted in connection with such means of escape must be so fitted that it can be readily opened. Every court or courtyard must be paved with impervious pavement, sloped to a properly constructed channel leading to a trapped gully grating, arranged so as to carry off all rain or waste water effectively. The pavement, channel and grating must be kept in good order and repair.

Every owner of a lodging-house shall cause every flight of stairs in every staircase in the lodging-house to be furnished, where necessary, with a sufficient handrail or handrails securely fixed. Other requirements are as in previous by-laws.

The London County Council have prepared new by-laws under Section 26 of the Act of 1919 (as amended by Section 14 of the Housing Act of 1923). They are (1925) awaiting confirmation by the Ministry of Health.

Working Class Lodging-houses.—As already noted, Part III. of the Housing of the Working Classes Act empowers the local authority to make by-laws for the management, use, and regulation of lodging-houses which they have established or acquired under that part of the Act.

Seamen's Lodging-houses.—Under the Merchant Shipping Act, 1894, a local authority whose district includes a seaport may, with the approval of the Board of Trade, make by-laws providing " for the licensing, inspection, and sanitary condition of seamen's lodging-houses, for the publication of the fact of a house being licensed, for the due execution of the by-laws, for preventing the obstruction of persons engaged in securing that execution, for the preventing of persons not duly licensed holding themselves out as keeping or purporting to keep licensed houses, and for the exclusion from licensed houses of persons of improper character." By-laws dealing with these matters are found useful in securing the sanitary condition of seamen's lodging-houses, and in protecting seamen against imposition. They have been made and enforced in a few seaport towns, and were brought into operation in London in 1901, at the instance of the London County Council.

VIII. **Cemeteries**—Section 2 of the Public Health (Interments) Act extended to cemeteries the provisions of the Act of 1875 relating to mortuaries, and hence made applicable to the former the powers given under Section 141 with respect to the latter. A model series of by-laws has been issued, which follows, in the main, the lines of the Home Office Regulations already referred to. The Board issued, in 1888, an important Memorandum on the sanitary requirements of cemeteries, reference to which has also already been made (see p. 738).

IX. **Mortuaries**—Section 141 of the Act of 1875 enables by-laws to be made as to mortuaries. The model series which has been issued by the Local Government Board contains a by-law dealing with the period within which bodies shall be removed from the mortuary (it is usual to specify five days from the date of death in non-infectious and three days in infectious cases); there are also by-laws for preventing misbehaviour of persons "viewing," or depositing, or removing bodies, and there is one requiring undertakers to convey empty shells from the premises without delay.

In a *Memorandum as to the Site and Structure and the Administrative Arrangements of Mortuaries* dated 25th July, 1882, the Local Government Board offer the following suggestions :—Care should be taken to make the buildings, as far as practicable, "isolated and unobtrusive"; they should be substantially constructed, and "in their external appearance attention should be paid to such architectural features as may serve to carry the impression of due respect for the dead." The chamber intended for the reception of corpses should be on the ground or basement floor; there should be provided a waiting-room, a caretaker's dwelling-house, and a shed or out-house for the keeping of shells, etc. A plan showing a mode of arranging the premises is appended to the Memorandum. It is, moreover, pointed out that the mortuary chamber should be constructed so as to ensure "convenience, decency, cleanliness and coolness." It should be lofty, with adequate floor space, and should have a ceiling, or, if open to the roof, there should be a double roof. Louvres, or air-gratings, under the eaves should be provided; the chamber should be lighted, if practicable, from the north side; the floor should be paved evenly and closely, a uniform cement floor being preferable; water should be laid on and shelves and tables (preferably made of slate slabs) provided; the ceiling and internal walls should be whitewashed and the outside of the roof whitened; the entrance to the chamber should be direct, without the intervention of any passage. There should be two chambers at least, an " infectious " and a " non-infectious " chamber, and these should be placed as far apart as may be practicable.

Section 143 of the Act of 1875 empowers a local authority to provide a post-mortem room otherwise than at a workhouse or a mortuary. The introduction of this limitation was no doubt suggested by the consideration that the provision of a post-mortem room in connection with a mortuary might tend to discourage the use of the latter by poor persons. The Public Health (London) Act, 1891, permits the construction of a post-mortem room in connection with a mortuary, and such an arrangement is obviously a convenient one. Under Section 143 of the Act of 1875 regulations (which do not require to be confirmed) may be made as to the management of the post-mortem room.

X. **Offensive Trades**—Model by-laws have been issued by the Local Government Board relating to certain trades.[1]

XI. **Tent and Van Dwellings; Housing of Hop-Pickers, Fruit-Pickers, etc.**—Section 9 of the Housing of the Working Classes Act of 1885 provides that " a Sanitary Authority may make by-laws for promoting cleanliness in, and the habitable condition of, tents, vans, sheds, and similar structures used for human habitation, and for preventing the spread of infectious disease by persons inhabiting the same, and generally for the prevention of nuisances in connection with the same." Tents, etc., used by military and naval forces are exempted from the operation of such by-laws.

The model series deals with the cleansing and ventilation of vans, etc.; provides that such structures shall be reasonably weather-proof, that the flooring or other covering of the ground shall be dry, that sufficient receptacles shall be provided for the storage of water, and that a sufficient supply of wholesome water shall be made available. It also provides for notification of infectious disease among inmates of vans, tents, sheds, etc.; it requires that any reasonable precautions ordered by the medical officer of health shall be complied with; it deals with the isolation of an infected person; and it provides for the medical officer of health exercising control over the movements of an infected van or tent, and for its cleansing and disinfection. The series also includes by-laws as to the disposal of refuse and filth; and for the protection of wells, springs, streams, etc., against pollution.

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[1] See p. 56.

Section 314 of the Act of 1875 empowers the local authority to make by-laws "for securing the decent lodging and accommodation of persons engaged in hop-picking within the district of such authority," and Section 2 of the Public Health (Fruit-Pickers' Lodgings) Act, 1882, extends the operation of the above-named section to pickers of fruit and vegetables. The model series dealing with these matters follows, broadly speaking, the series relating to tents and vans. It may be noted, however, that it requires "sixteen square feet at the least of available floor space in respect of each adult person"; it makes provision for adequate privacy when adult persons of different sexes are accommodated; it contains requirements as to cooking places—a cooking-house is to be provided for every fifteen persons—and it makes reference to the need of furnishing a sufficient supply of clean, dry straw, or other clean, dry, and suitable bedding.

XII. **Public Slaughter-houses**—Section 169 of the Act of 1875 requires an urban authority to make by-laws for the management, and charges for the use, of any slaughter-houses provided by them. No model series has been issued by the Board under this heading.

XIII. **By-laws under the Public Health Acts Amendment Act, 1890**—Under Section 23 of this Act Section 157 of the Act of 1875 is extended so as to empower urban authorities to make by-laws with respect to—

The keeping of water-closets supplied with sufficient water for flushing;

The structure of floors, hearths and staircases, and the height of rooms intended to be used for human habitation;

The paving of yards and open spaces in connection with dwelling-houses; and

The provision, in connection with the laying out of new streets, of secondary means of access, where necessary, for the purpose of the removal of house refuse and other matters.

Further, by-laws under Section 157, as thus extended (with regard to drainage, water-closets, etc., and the flushing of water-closets), may be made to affect old buildings, and the provisions of the section, as amended (so far as they relate to the structure of walls and foundations of new buildings for purposes of health; to sufficiency of air space about buildings, and to the ventilation of buildings; to drainage, water-closets, etc., and the closing of buildings unfit for human habitation; to the structure of floors, the height of rooms, and the keeping of water-closets supplied with sufficient water for flushing) are extended so as to empower rural authorities to make by-laws in respect to the said matters. Moreover, by-laws may be made preventing buildings "erected in accordance with by-laws under the Public Health Acts, from being altered in such a way that if at first so constructed they would have contravened the by-laws."

Model by-laws have been issued for the above objects also in respect to the drainage of existing buildings, and further as to new buildings and certain matters in connection with buildings in rural districts.

Again, under Section 26 of the Act of 1890, an urban authority may make by-laws—

"(*a*) For prescribing the times for the removal or carriage through the streets of any fæcal or offensive or noxious matter or liquid, whether such matter shall be in course of removal or carriage from within or without or through the district.

(*b*) For providing that the vessel, receptacle, cart, or carriage used therefor shall be properly constructed, and covered so as to prevent the escape of any such matter or liquid.

(*c*) For compelling the cleansing of any place whereon such matter or liquid shall have been dropped or spilt in such removal or carriage."

No "models" have been issued, but by-laws relating to these subject-matters are in force in various places, and similar by-laws have been made under the Public Health (London) Act, 1891. The principle of insisting on the performance of scavenging operations during the hours of the early morning has usually been accepted; it may be further noted that stable manure has commonly been exempted from the operation of the by-laws.

Section 26 (2) of the Act of 1890 provides that, where the local authority themselves undertake or contract for the removal of house refuse, they may make by-laws imposing duties on the occupier so as to facilitate the work. Here, again, no model series has been issued, but by-laws have been confirmed requiring occupiers at specified times to deposit, in a place prescribed, movable receptacles of a capacity not exceeding (say) six cubic feet, containing the house refuse which may have accumulated.

Finally, the Act of 1890, Section 20, authorises the making of regulations concerning the management and use of public sanitary conveniences. Such regulations usually deal with questions of decent conduct, the payment of fees, writing or fixing bills, etc., on walls, damage to fittings, the duties of attendants, cleansing operations, and the like.

Dairies, Cowsheds, and Milk Shops Orders—Section 34 of the Contagious Diseases (Animals) Act, 1878, empowered the Privy Council to make Orders for the registration of cowkeepers, dairymen, and purveyors of milk; for the inspection of cattle in dairies; for the lighting, ventilation, cleansing, drainage, and water supply of dairies and cowsheds; for securing the cleanliness of milk stores, milk shops, and milk vessels; for prescribing precautions to be taken for protecting milk against infection or contamination; and for authorising a local authority to make regulations for the purposes aforesaid, or any of them. Section 9 of the amending Act of 1886 transferred the powers above specified from the Privy Council and the local authorities under the Contagious Diseases (Animals) Act, 1878, to the Local Government Board, and the several urban and rural Sanitary Authorities. The Orders in force at the present time are that made by the Privy Council in 1885, in substitution for an earlier Order made in 1879, the amending Order, issued in 1886 by the Local Government Board, and the amending Order of 1899.

The main provisions relating to the matters in question are contained in the Order of 1885; the Order of 1886 is concerned with the above-mentioned substitution of authorities and contains a penalty clause. Under the 1885 Order it is declared unlawful to carry on the trade of a cowkeeper, dairyman, or purveyor of milk without previous registration, and the local authority is required to keep a register, and to give notice by advertisement that registration must be effected, etc.; a person who sells milk of his own cows in small quantities, to his workmen or neighbours for their accommodation, is not required to be registered. The Order assigns to the local authority powers of control as regards the lighting, the ventilation, including air space, and the cleansing, drainage, and water supply of new dairies and cowsheds, and requires that one month's notice shall be given of the intention to occupy a new building as a dairy or cowshed. It also assigns more limited powers in regard to buildings already occupied as dairies or cowsheds. It prohibits any person suffering from dangerous infectious disease, or having been in contact with a person so suffering, from milking cows or assisting in the conduct of a milk business. The Order further deals with the question of possible contamination from communication of water-closets, etc., with milk stores and milk shops; with the use of the places last named as sleeping apartments; and with the keeping of swine in cowsheds or places used for keeping milk for sale. It authorises the making of regulations, and it prohibits the milk of a diseased cow being mixed with other milk sold or used for human food, or sold or used as food for animals, until it has been boiled.

The Report of the Royal Commission on Tuberculosis, 1898, draws attention to the need of requiring a proper amount of cubic space in cowsheds. The Commissioners suggested, however, that a distinction should be made between cowsheds situated in populous and those situated in non-populous places; they further pointed out that the term "disease," in the Order of 1885, was limited to diseases included under the Contagious Diseases (Animals) Act of 1878, of which tuberculosis is not one, and they recommended that the Order "should be made applicable to all diseases of the udder in cows of which the milk is offered for sale."

The Local Government Board issued an amending Order in 1899, extending the definition of disease so as to include "such disease of the udder as shall be certified by a veterinary surgeon to be tubercular," and the Board, in a circular letter to borough and urban and rural district councils, dated March, 1899, express the opinion that "it will be competent for the council to employ and pay a veterinary surgeon with a view to obtaining a certificate under the article as amended, or to appoint him as an officer for this purpose, if they think fit to do so."

Manchester, in 1899, and numerous towns since that date, have obtained powers in private Bills relating to tuberculous milk. The "Manchester Milk Clauses" provide that the milk of a cow known to be suffering from tuberculosis of the udder must not be used for human food; they give power to inspect and to take samples of milk within the city, and outside it, on production of the order of a justice having jurisdiction in the place in which the farm is situated, and they impose on dairymen supplying milk within the city the duty of notifying cases of tuberculous disease of the udder to the medical officer of health.

The *Model Regulations* issued in 1899 by the Local Government Board deal with the inspection of cattle in dairies, and with the lighting, ventilation, cleansing, drainage, and water supply of cowsheds and dairies. Distinction is made, as regards overcrowding, between cowsheds the cows from which are habitually grazed on grass land during the greater part of the year, and when not so grazed are habitually turned out during a portion of each day, and other cowsheds. As regards the latter, and for them only, it is prescribed that 800 feet of air space for each cow shall be provided, and that no space shall be reckoned which is more than 16 feet above the floor; if "the roof or ceiling is inclined, then the mean height of the same above the floor may be taken as the height thereof" for the purposes of the regulation. Further, the requirement is not to apply to old cowsheds until two years after the date when the regulations come into force.

There are, moreover, in the model series, regulations concerning cleanliness of milk stores, milk shops, and milk vessels, and there is, further, one requiring reasonable and proper precautions to be taken by purveyors of milk and persons selling milk by retail in connection with the storage and distribution of milk. This last-named regulation specifically prohibits milk intended for sale being deposited or kept—"(*a*) in any room or place where it would be liable to become infected or contaminated by impure air, or by any offensive, noxious, or deleterious gas or substance, or by any noxious or injurious emanation, exhalation, or effluvium; or (*b*) in any room used as a kitchen or living-room; or (*c*) in any room or building or part of a building communicating directly by door, window or otherwise with any room used as a sleeping-room, or in which there may be any person suffering from any infectious or contagious disease, or which may have been used by any person suffering from any such disease and may not have been properly disinfected; or (*d*) in any room or building or part of a building in which there may be any direct inlet to any drain." Milk must not be kept in any vessel which is not thoroughly clean and vessels must be cleansed with steam or clean boiling water after use. Finally, it is provided that no cow shall be milked for the purpose of obtaining milk for sale—

"(*a*) unless at the time of milking the udder and teats of such cow are thoroughly clean; and

(*b*) unless the hands of the person milking such cow, also, are thoroughly clean and free from all infection and contamination."

The Milk and Dairies (Consolidation) Act, 1915, which however does not come into force before September, 1925, withdraws the powers granted to a number of urban authorities, known as the Model (Manchester) Milk Clauses, and re-arranges them so as to make them dependent on the joint action of the local authority in whose district evidence of tuberculous milk is discovered, and of the authority in whose district the farms from which the infection is believed to have arisen lie. In effect, their value will be diminished so far as the district receiving the tuberculous milk is directly concerned, and will depend on the activity and alertness of individual County Councils in the discovery of tuberculous udders. So far, no evidence has been produced showing that agricultural areas have made any effort to protect the places supplied by them with milk, although they possess the powers under the Model By-laws, 1885 and 1886. The powers conferred by Section 1 on the Ministry of Health to make general or special orders in regard to a number of matters embracing, *inter alia*, the subjects now covered by the Dairies, Cowsheds, and Milkshops Order, 1885, and regulations made under that or a previous order, are not, therefore, necessarily postponed to the year 1925.

In fact, the Milk and Dairies (Amendment) Act, 1922, has these important provisions. A local authority has power to refuse registration of or remove from the register a retailer of milk, if satisfied that the public health is or is likely to be endangered, by any act or default of the person registering or seeking to be registered, in relation to the quality, storage or distribution of milk. There is an appeal. A court may, in respect of offences under this Act, or under other enactment, relating to milk and dairies, order removal of a person convicted from the register. The effect of such action would be that the person concerned ceases to be a milk dealer.

MATERNITY AND CHILD WELFARE

The medical profession had long been deeply concerned about the inadequacy of the midwifery service, and the consequent risks to which women were exposed in pregnancy as well as during and after confinement. The Midwives Act, 1902, was therefore passed to regulate and control the practice of midwives. In 1918, a further Act was passed to remove some difficulties which had arisen.

The Midwives Acts, 1902 *and* 1918, provide for the constitution of the Central Midwives Board, and devolve the local administration of the Act on supervising authorities, *i.e.*, county councils, county boroughs, and in the case of London on the Administrative County.

The duties of the Local Supervising Authority under the Midwives Act, 1902, are :—

(i) To exercise general *supervision over all the midwives*[1] practising in the area. As a rule the midwives should be visited once a month in their homes ; attention should first be paid to the sanitary condition of the house ; next to the condition of the midwife's bag of appliances, registers, clothes and personal appearance ; lastly, definite practical instruction should be given in the Rules of the Central Midwives Board, if necessary. If the midwife is out at a case, the inspector of midwives should go to the patient's house to see if the labour is conducted properly. Visits should be paid to mothers during the lying-in to see that the midwife carries out her duties satisfactorily. In practice most of the time taken up in inspecting midwives will be devoted to the untrained midwife.

Special visits will be required to mothers with puerperal fever, babies with ophthalmia neonatorum, in the event of the death of a patient or delay in sending for medical help and in the case of stillbirths.

(ii) To investigate charges of malpractice, negligence and misconduct on the part of any midwife. Repeated misconduct, gross neglect or carelessness must be reported to the Central Midwives Board, who may censure the midwife or cancel her certificate temporarily or remove her name from the Midwives' Roll.

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[1] Up to April, 1905, midwives possessing certain qualifications were entitled to be certified, also midwives without a qualification who had been for at least one year in *bona fide* service as a midwife and bore a good character. After that date any uncertified woman using any title implying that she is a person specially qualified to practise midwifery is liable to a penalty.

After April 1st, 1910, no woman unless certified under the Act is allowed habitually and for gain to attend women in childbirth, otherwise than under the direction of a qualified medical practitioner, under a penalty. A certified woman may not employ an uncertified substitute. After April 1, 1905, all certificates must be obtained by an examination under the Central Midwives Board.

(iii) To suspend any midwife from practice in accordance with the rules of the Act if such suspension appears necessary to prevent the spread of infection.

(iv) To report at once to the Board the name of any midwife practising in the area convicted of an offence.

(v) During the month of January of each year to supply the Secretary of the Board with the names and addresses of all midwives who, during the preceding year, have notified their intention to practise within the area.

(Before commencing practice in an area a midwife must notify the medical officer of health of her intention of doing so. This notice must be repeated in December of each year.)

(vi) To report at once to the Board the death or any change in name or address of any midwife in the area.

The chief enactments of the Midwives Act, 1918, are as follows :—

By Section 6 (1) the Central Midwives Board are empowered to frame rules authorising that Board to suspend a midwife from practice for such period as they think fit, instead of striking her name off the roll and to suspend her pending the decision of her case.

By Section 6 (2) where a midwife has been so suspended from practice and the case is decided in her favour, or where a midwife has been suspended from practice in order to prevent the spread of infection, the Central Midwives Board or the local supervising authority may, if they think fit, pay her reasonable compensation.

By Section 7 local supervising authorities are to supply midwives gratis with forms and books which certified midwives are required to fill up and use (other than forms required to be returned to the Central Midwives Board), duly stamped or accompanied with a stamped envelope where the form is required to be returned by post.

By Section 9 every certified midwife who gives notice of intention to practise and subsequently changes her address, must within 7 days notify her new address to each supervising authority in whose district she has given notice of intention to practise, subject to a fine not exceeding £2.

By Section 11 local supervising authorities are empowered to aid the training of midwives whether within or without their area, and to make grants for the purpose.

Section 12 repeals section 9 of Act of 1902 permitting delegation of duties under the Act by the County Council to smaller authorities.

Section 14 requires a midwife in any emergency to call in a registered medical practitioner, and requires the supervising authority in such cases to pay the practitioner's fee according to a scale fixed by the Local Government Board.

The local supervising authority are empowered to recover the fee from the patient or her husband, or other person liable to maintain her unless they are satisfied that any of them cannot afford the sum.

The Act of 1902 provided for the formation of the Central Midwives Board, who were empowered, *inter alia*—

(i) To frame rules regulating the issue of certificates and the conditions of admission to the roll of midwives, the course of training, and the conduct, etc., of examinations, admission to the roll of women already in practice as midwives at the passing of this Act and the regulating, supervising and restricting within due limits the practice of midwives, deciding the conditions under which midwives may be suspended from practice, defining the particulars to be given in any notice of intention to practise in an area.

(iv) To publish annually a roll of midwives who have been duly certified under this Act.

(v) To decide upon the removal from the roll of any midwife for disobeying the rules and regulations laid down under this Act, or for other misconduct, and also on the restoration of any name to the roll.

The rules which the Central Midwives Board were directed to frame appeared in due course. Section E20 and 21 prescribes the emergencies in which a midwife must advise that a doctor is to be called in and the mode in which this is to be done. The local supervising authority must be notified as soon as possible (i) when medical help has been sent for; (ii) in all cases of death of the mother or child or when a stillbirth occurs before the attendance of a medical practitioner; (iii) in all cases in which the midwife has prepared a dead body for burial, or whenever a midwife has, in the course of her work, become liable to be a source of infection, so that suitable precautions may be taken; (iv) when it is proposed to substitute artificial feeding for breast feeding; (v) when the midwife, whether practising or not, has changed her name or address. Amongst other emergencies in which she must advise in the prescribed manner that a medical practitioner is to be sent for is included the presence of inflammation or discharge from the eyes however slight.[1]

As regards appliances, a suitable midwifery bag must be provided with a clean and detachable lining, and must not be used for any other purpose. The contents of the bag should include: Vaginal douche can or siphon douche with a glass nozzle (the practice of daily routine douching of women after labour should be discouraged), catheter, thermometer, Higginson's syringe (this should be used for giving enemas only and should be wrapped up in a separate linen bag), a pair of scissors and a nail-brush. In the case of untrained midwives, the local supervising authority may use their discretion as to requiring them to carry a catheter and vaginal douche can.

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[1] Attention was at once directed to ophthalmia neonatorum by the Act, and this condition was made notifiable by the L.G.B. in 1914.

Suitable provision of washing dresses and aprons should be insisted upon ; the sleeves of the dress must be made so that they can be tucked up well above the elbows, and where gloves are worn these must be washable. Care must be taken to secure proper storage of the midwife's clothes. She should be urged to take a bath at least twice a week and to keep her hair well washed. A careful examination should be made of her hands and nails ; she should be encouraged to keep them in good order and to take precautionary measures against any chapping of the hands.

Midwives should carry their bag with them on each visit to the patient during the lying-in. Any practice of carrying a few utensils in the pocket of the apron or in a small satchel should be prohibited. The midwife should always carry with her a nail-brush and sufficient antiseptics ; the dangers of carrying the infection of ophthalmia, septic skin rashes, etc., is real, and the only way to prevent the danger is by thorough disinfection of the midwife's hands at the home of each patient.

When a case of puerperal fever occurs, the personal clothing and bedding of the midwife should be removed to the disinfecting station of the local authority and disinfected. The midwife should be instructed to have two disinfectant baths, paying special attention to her hair, nostrils, and nails. The inspector should personally supervise the disinfection of the midwife's hands and arms. They must be washed for five minutes in soap and water, then for five minutes in a suitable disinfectant, such as lysol, and finally, after the soap has been rinsed off, soaked in corrosive sublimate solution (1 in 1,000) and the appliances sterilised or disinfected by the inspector. Suspension if carried out lasts about forty-eight hours as a rule (notice must always be sent to the Central Midwives Board, giving the reason and period of suspension if over twenty-four hours). If the midwife has failed to comply with the Rules of the Central Board she should be summoned to attend before the Committee and admonished, but, if a *prima-facie* case of neglect is established, a report should be sent to the Central Midwives Board.

Midwives are also suspended in order to prevent possible infection of their patients with any other disease. Causes for suspension include a dirty condition of a midwife's home, bag or appliances, the occurrence of several cases of ophthalmia or pemphigus neonatorum in a midwife's practice, or attendance on women who develop infectious disease such as scarlet fever. Rule 18 prohibits the laying out of dead bodies or preparation of stillbirths for burial other than in her own cases. The midwife should not dress septic sores or burns.

Cellulitis of the arm or hand, whitlows, septic burns, paronychia, sores, all prevent a midwife carrying on her work ; pyorrhœa and a discharge from the ears require consideration. Not only is there a danger of infecting the mother, but disease may be set up in the baby. Conjunctivitis may occur; the umbilicus may become septic or the baby develop pemphigus neonatorum. As an example of the extent to which suspensions from practice are required, in 1914 in Manchester, when 161 midwives attended 9,409 births, 117 suspensions were made. The reasons were as follows:—Puerperal fever, 56; pemphigus, 26; high temperature, 11; other infectious diseases, 21; and one on account of the midwife having a septic arm, and another because the midwife's house was dirty and her appliances were inadequate. In two instances the midwife's stock of washing dresses and aprons were insufficient to ensure cleanliness. In 1922, 203 suspensions occurred.

A recent circular of the Ministry advised that maternity nursing by trained midwives should be encouraged whether a doctor is engaged or not, and the employment of unqualified "maternity nurses" should be controlled as far as practicable. It may be desirable to employ specially skilled nurses for the home nursing of complicated cases.

The difficulty which formerly existed as to whom should pay the fee of the doctor, called in to help the midwife, has now been settled by Section 14 of the Midwives Act, 1918. Failure or delay in sending for medical help is still responsible for the unnecessary prolongation of labour and subsequent illness or even death of the mother or child.

The following list of the number of times medical aid was called in Manchester in 1922 by midwives, and the reasons, affords some indication of the extent to which they can be educated in this important part of their duties.

Pregnancy:	
Abortions, miscarriages	23
Deformed pelvis	16
Loss of blood	18
Other unusual features of pregnancy	105
Labour:	
Presentations:	
Head-malposition	33
Breech	48
Transverse	10
Cord	27
Unable to make out	12
Footling	8
Hand	10
Tedious labour	498
Placenta:	
Retained	42
Adherent	40
Prævia	7
Membranes retained	18
Rupture of perineum	742

Hæmorrhage :	
Ante-partum	62
Post-partum	31
Hæmorrhage—3rd stage	9
Convulsions	17
Complications	44
Premature labour	20
Lying-in :	
Abdominal swellings	1
Foul smelling discharges	2
Secondary post-partum hæmorrhage	4
Rigor	1
Rise of temperature above 100·4° F.	85
Unusual swelling of breasts	9
Progress unsatisfactory or complications	293
Newly born child :	
Injuries received during birth	1
Obvious malformations	67
Tongue-tied	47
Feebleness of child	157
Inflammation of eyes and eyelids	471
Skin eruption	89
Illness through prematurity	91
Jaundice	54
Inflammation about the umbilicus	19
Unspecified or complications	196
Convulsions	45
Totals	3,472
Total number of births attended by midwives	9,578

Some large authorities, including Manchester and Liverpool, appoint a special nurse or nurses to visit the homes and help the mothers cleanse the eyes of babies suffering with ophthalmia neonatorum and to arrange for the hospital admission of suitable cases.

In Manchester, in addition to the special nurses for ophthalmia neonatorum, two other nurses are appointed for maternity work. Patients with a rise of temperature are taken over from midwives until diagnosed as septic or non-septic. The nurse visits night and morning, washes the private parts, tidies the patient, washes the baby, takes the temperature and pulse and reports in writing to the doctor in charge and to the executive officer daily. If a septic case is treated at home the nurse continues to visit. Patients with an abscess of the breast are attended when a district nurse is not available. In certain cases of white leg the nurse attends night and morning; patients with varicose ulcer, eczema and erysipelas are also nursed.

Babies with a skin eruption or discharging umbilicus are attended daily and the babies washed and the sores dressed, the nurse being careful not to attend to the mother. Babies with spina bifida are also nursed. When the mothers are in hospital with puerperal fever the baby left at home is visited and washed daily. Emergency maternity cases are conducted when the midwife engaged is unable to attend by reason of sepsis or illness.

Other enactments bearing upon maternity include the Factory and Workshop Act, 1901, which requires that an occupier of a factory or workshop shall not knowingly allow a woman or girl to be employed therein within four weeks after she has given birth to a child. By the National Insurance Act, 1913, every approved society and insurance committee must make rules requiring any woman in respect of whom the maternity benefit is payable (the wife of an insured person, or an insured woman) to abstain from remunerative work during a period of four weeks after her confinement. In the case of an insured woman who becomes pregnant, if incapacity exists through pregnancy, a certificate from her panel doctor entitles her to sickness benefit.

Allusion should, again, be made to maternity benefit under the National Insurance Act, which, in the case of a married woman, amounts to 42*s.* if her husband is insured, or if she is confined of a posthumous child. If she is insured and her husband is also insured, she is entitled to an additional benefit of 42*s.* An insured woman whose husband is not insured, is, also, entitled to two maternity benefits, £4 4*s.* in all from her own Society. Further, if her husband is insured, but for any reason less than 42*s.* is payable in respect of his insurance, the amount is made up to £4 4*s.* by the wife's Society. If the mother is unmarried, but insured, she is entitled to 42*s.* maternity benefit. Maternity benefit belongs to the woman. It is not paid if, at the time of the confinement, the person on behalf of whose insurance it is claimed, has been insured for less than 42 weeks. A woman is not entitled to any sickness or disablement benefit for the period of 4 weeks following her confinement, except in the case of an unmarried woman whose incapacity is not connected directly or indirectly with her confinement.

A maternity hospital or home is needed for two purposes : (i) to deal in the best manner with emergencies, and (ii) to receive normal cases in which the home conditions are unsuitable. These needs are general, and the Ministry of Health therefore issued a Memorandum on this subject in 1920 with model plans for (1) a combined maternity and child welfare centre, (2) maternity hospitals of small sizes, (3) a maternity hospital for 120 beds, (4) a maternity home for 22 beds.[1]

In large communities, labour is often conducted in private *lying-in homes* under unsuitable conditions. In the London County Council (General Powers) Act for 1921, powers were obtained to control such homes and to forbid their use for that purpose unless registered with the Council. The Council might, however, refuse to register for certain specified reasons.

The Council may make by-laws prescribing the records to be kept of the business carried on at lying-in homes, the number of patients to be accommodated, and the equipment to be provided thereat, and requiring the notification to the Council of any death occurring thereat. A copy of the by-laws must be kept in a suitable place approved by the Council. A penalty is imposed for infringement and obstructing an authorised officer of the Council ; carrying on a lying-in home in contravention of the provisions of the by-laws and advertising an unregistered lying-in home; and in the case of a registered house, the registration may be cancelled. These clauses do not relate to a lying-in home kept by a medical practitioner who fulfils certain conditions. Certain hospitals, institutions, and homes are exempt from these powers which are in lieu of clauses in the Act of 1915 (repealed). Manchester also obtained powers in their Act of 1921 similar to the above.

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[1] See also "Hygiene for Health Visitors," Hutt, p. 332.

INFANT AND CHILD WELFARE

Much social legislation, especially affecting child welfare, was passed during the early years of the present century. In 1903 an Act was passed dealing with the employment of children, particularly in regard to street trading. In 1904 an Act was passed dealing with cruelty to children, the principal provisions of which were embodied in the Children Act, 1908, a consolidating measure. The report of the Royal Commission on Physical Training (Scotland) Act, 1903, which contained the investigations of Leslie Mackenzie into the physical condition of school children in Edinburgh, and the parallel report by Hay for Aberdeen, produced a general feeling of alarm, and was followed in England by the appointment of the Interdepartmental Committee on Physical Deterioration, 1904. The direct result of these inquiries was the establishment of a School Medical Service under the Education Act, 1907. Meanwhile general attention was directed to the condition of children under school age which was, of course, closely related to that of school children, and especially to infantile mortality. Under the London County Council (General Powers) Act, 1908, local authorities in the Metropolis were empowered to appoint health visitors for the purpose of instructing and guiding mothers in the management of their children and homes. Consultation centres were established to which mothers brought their babies and young children, to be weighed and examined by medical officers specially versed in a knowledge of infantile ailments. Antenatal instruction and examination had made little progress except perhaps in large centres of population where it formed part of the work of a lying-in hospital.

In 1914, following up their reports on infant mortality and child welfare, a circular was issued by the Local Government Board offering a grant to local authorities in respect of those activities which then appeared most necessary and useful. A memorandum sent out at the same time pointed out that a complete scheme would comprise the following elements, each of which would in this connection be organised in its direct bearing on infantile health.

(1) Arrangements for the local supervision of midwives.

(2) Arrangements for—

Antenatal
- (1) An antenatal clinic for expectant mothers.
- (2) The home visiting of expectant mothers.
- (3) A maternity hospital or beds at a hospital in which complicated cases of pregnancy can receive treatment.

Natal . .
- (1) Such assistance as may be needed to ensure the mother having skilled and prompt attendance during confinement at home.
- (2) The confinement of sick women including women having contracted pelvis or suffering from any other condition involving danger to the mother or infant, at a hospital.

Post-natal
- (1) The treatment in a hospital of complications arising after parturition, whether in the mother or in the infant.
- (2) The provision of systematic advice and treatment for infants at a baby clinic or infant dispensary.
- (3) The continuance of these clinics and dispensaries, so as to be available for children up to the age when they are entered on a school register, *i.e.*, the register of a public elementary school, nursery school, crêche, day nursery, school for mothers, or other school.
- (4) The systematic home visitation of infants and of children not on a school register as above defined.

A further circular was issued on September 23, 1916, along with regulations under which grants will be paid by the Local Government Board in aid of maternity and child welfare work.

Regulation (1) runs: "The Local Government Board will pay grants in respect of the following services:—

(1) The salaries and expenses of midwives.

(2) The salaries and expenses of health visitors and nurses engaged in maternity and child welfare work.

(3) The provision of a midwife for necessitous women in confinement, and for areas which are insufficiently supplied with the service.

(4) The provision of a doctor for the aid in confinement of necessitous women.

(5) The expenses of a centre, *i.e.*, an institution providing any or all of the following activities, *viz.*, medical supervision and advice for expectant and nursing mothers, and for infants and young children, and medical treatment at the centre for cases needing it.

(6) Hospital treatment provided or contracted for by a local authority for complicated cases of confinement or complications arising after parturition, either in the mother or infant, and for infants found to need in-patient treatment."

These offers from the Board were bound to and did produce a large number of schemes throughout the country.

A memorandum on health visiting and on maternity and child welfare centres by the Medical Officer of the Board, dated November, 1915, set out in full detail the manner in which the work should be carried on. Subsequent measures were directed to extending and regulating the action of local authorities.[1] The Maternity and Child Welfare Act, 1918, especially requires that the provision of schemes for maternity and child welfare, so far as relates to ages between birth and five years, shall be made to cover all areas.

Maternity and child welfare committees, one-third of whose members might be co-opted for their special knowledge of the subject, were established.

It is obviously convenient, though not here enacted, that the midwives' supervising committee should form a section of the committee, though it will be observed that the local authorities are generally different for the above Act and the Midwives Acts. A memorandum dated 9th August, 1918, issued by the Local Government Board, announces that the grant is now available for additional services, and enumerates: Hospital treatment for children up to five years of age; lying-in homes; the provision of food for expectant and nursing mothers and for children under five years of age, and crêches and day nurseries; convalescent homes; homes for the children of widowed and deserted mothers and for illegitimate children; experimental work for the health of expectant and nursing mothers and of infants and children under five years of age. Home nursing services are considered. Only minor ailments are to be treated at centres, but experimental provision of cots may be tried. The provision of home helps who should be specially trained is contemplated. The list of services for which the Board will pay grant is revised to take in the additions already named.

Circular 557 explaining Memo. $\frac{101}{\text{M. \& C.W.}}$ of February, 1925, states that on and after the 1st of April, 1928, the Minister of Health will not approve the appointment of a woman for the first time as a whole-time officer of a Local Authority with health visiting duties unless she has obtained the certificate obtained by passing an examination to be conducted by a central examining body approved by the Minister for this purpose.

To be eligible for this examination (i) she must be a trained nurse

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[1] The following circulars and memoranda are to be noted:—Memorandum in regard to day nurseries, Ministry of Health, November, 1919. Memorandum on Maternity and Infant Welfare Centres, Ministry of Health, November, 1919; Grants in aid of the training of midwives, Circular No. 10, 1919.

(as defined on p. 3 of the Memo.) who has obtained the certificate of the Central Midwives Board and has completed an approved course of training in public health work lasting for at least six months or she must have undergone a course of training of two years' duration already recognized under the Board of Education (Health Visitors' Training) Regulations, 1919 (those mentioned below), together with six months' training in a general, fever or children's hospital providing such training, and have obtained the certificate of the Central Midwives Board.

The Ministry of Health make grants to recognized educational bodies organizing courses of training for health visitors.

Existing whole-time health visitors, or other women who have worked satisfactorily as health visitor and school nurse or tuberculosis nurse for five years, may enter for the examination without attending any special course of instruction.

Attendance at refresher courses of 2–4 weeks by already appointed health visitors, the Minister is anxious should be encouraged; local authorities are enabled to pay the reasonable expenses of their health visitors for this purpose.

District nurses employed as health visitors in rural parishes not being whole-time health visitors are not required to obtain the qualification but should be enabled to attend these courses.

This circular mentioned above postulates the appointment of health visitors.

The power of Sanitary Authorities to appoint Health Visitors was first granted in London under the London County Council (General Powers) Act, 1908. Any Sanitary Authority (*i.e.*, City of London and Metropolitan Boroughs) may on or at any time after the first day of January, 1909, appoint suitable women (to be known as Health Visitors) for the purpose of giving to persons advice as to the proper nurture, care and management of young children and the promotion of cleanliness, and discharging such duties (if any) as may be assigned to them in accordance with the provisions of this section.

The Local Government Board may make regulations prescribing the qualifications, mode of appointment, duties, salary and tenure of office of Health Visitors appointed under this section, and no appointment of a Health Visitor shall be made otherwise than in accordance with such regulations.

The regulations have recently been modified by Memo. $\frac{65}{\text{M. \& C.W.}}$ of July, 1922, which states that the qualifications which will be required on and after January 1st, 1923, are :—

5. (i) The certificate prescribed by the Regulations of the Board of Education.
   (ii) Three years' training in a General Hospital, or full training in a Children's Hospital, together with at least one of the following qualifications :—
      (*a*) the certificate of the Central Midwives' Board,
      (*b*) the certificate of a Sanitary Inspector,
      (*c*) the certificate for Health Visitors of one of the bodies approved by the Local Government Board under the Health Visitors (London) Order, 1909, *i.e.*, the Royal Sanitary Institute, the Royal Institute of Public Health, the National Health Society, or the Battersea Polytechnic.

For the present the Minister will be prepared to dispense with the full qualifications referred to in (i) and (ii) in special cases in which evidence is submitted that a woman whom it is proposed to appoint as a Health Visitor has had previous experience of the duties under a local authority and has discharged them efficiently.

Registration of Births—The Births and Deaths Registration Act, 1874, requires that the birth of a living child shall be reported to the local registrar within 6 weeks of birth. This duty is placed upon the father, the mother, the occupier of the premises where the birth took place, or any person present at the birth or having charge of the child. If a baby dies soon after birth, both the birth and the death must be registered, and a death certificate obtained from a doctor. Stillbirths need not be registered. Before the body may be buried a written certificate of the doctor who attended at the birth or who examined the body after birth must be produced, or a form of declaration obtained from the local registrar signed by the father or mother, or in default of these the occupier of the house in which the birth took place, or a person who was present at the birth.

By the Notification of Births (Extension) Act, 1915, the previous Act of 1907 ceased to be adoptive, and on and after the first day of September, 1915, was extended to and took effect in every area in which it was not already in force. Where it came into force in any county district in which it was not already in force, the medical officer of health was required to send duplicates of all notifications received by him to the county medical officer of health. Notification under these Acts is to be given by the father of the child, or failing him by any person in attendance upon the mother at the time of, or within six hours after the birth, and it is to be given by posting a prepaid letter or post-card addressed to the medical officer of health at his office or residence, within thirty-six hours of birth. This applies to the birth of any child after the twenty-eighth week of pregnancy, whether born alive or dead. The local authority must supply addressed and stamped post-cards containing the form of notice to any medical practitioner or midwife residing or practising in their area who applies for the same. Notification is on the whole well carried out. Arguments have been put forward for giving up registration of births, but notification and registration act as a check upon one another, and both are really required.

In February, 1918, under war conditions *the supply of milk under cost by local authorities to mothers and children* was both required and regulated by the Milk (Mothers and Children) Order, made by the Food Controller and the Local Authorities (Food Control) Order issued by the Local Government Board.

In March, 1921, the Ministry of Health issued a second circular, curtailing the amounts allowed by the first and further regulating the supplies.

One pint of milk daily is to be allowed to expectant mothers in the last three months of pregnancy and to nursing mothers and to each child under three years of age; in exceptional cases infants between three and eighteen months of age may be given one and a half pints daily ; between the ages of three and five years a pint of milk may be granted to each child for whom a special medical certificate is forthcoming. Scales of necessity must be drawn up in order to distinguish those persons to whom the milk might be supplied at less than cost price or free and submitted for the approval of the Ministry. Strict administration is needed to ensure that this assistance is not misspent.

The Protection of Children—The Infant Life Protection Act, 1897, the Prevention of Cruelty to Children Act, 1904, and the Children Act, 1908, made provision in other ways for the protection of children, including infants. The Children Act of 1908 is a consolidating measure and includes the provisions made in previous Acts. Part I. relates to children under the age of seven years, the nursing and maintenance of whom has been undertaken by any person apart from their parents for reward. Such person must give notice to the local authority within 48 hours, stating the name, sex, date and place of birth of the infant, the dwelling within which the infant is being kept, and the name and address of the person from whom the infant has been received. If the person receiving the infant changes his residence, he must within 48 hours give to the local authority notice in writing of the change, and also to the local authority of the district into which he has moved. If the infant dies or is removed from his care, he must give notice to the local authority within 48 hours, and in the latter case must also notify the name and address of the person to whose care the infant has been transferred. Notices previously given under the Infant Life Protection Act, 1897, and obligations incurred, are transferred to this Act. A local authority must appoint visitors, and seek out cases in their district in which the keeping of children has been undertaken for reward. Certain unsatisfactory persons are prohibited from keeping infants, who are also not to be kept in certain unsuitable premises. A local authority may fix the number of infants who may be kept. If a visitor finds that an infant is kept in unsuitable premises or by unsuitable persons, he may apply to a justice or to the local authority for an order to have the infant restored to its relative or removed to a place of safety. A penalty is imposed on failure to give the requisite notices, on any person keeping an infant for reward for insuring or attempting to effect an insurance on its life either personally or indirectly, on any company issuing such an insurance, and the giving of any false notice or obstruction to a visitor in discharge of his duties. On the death of an infant notice must be given to the coroner within twenty-four hours of the death. The local authorities for the purposes of this part of the Act are :—(*a*) as respects the County of London, exclusive of the City, the County Council; (*b*) as respects the City of London, the Common Council; (*c*) elsewhere the guardians of the poor law union. Certain persons and institutions are exempted from these provisions and the local authority may exempt any person or institution from being visited as they think fit.

Part II. relates to cruelty to children and young persons. Any person over 16 years of age having the custody, charge, or care of any child (under 14 years of age) or young person (under 16 years of age) wilfully assaulting, ill-treating, neglecting, abandoning, or exposing such a child, etc., in a manner likely to cause the child, etc., *unnecessary suffering or injury to his health* (including injury to or loss of sight, or hearing, or limb, or organ of the body, and any mental derangement), shall be liable to a penalty.

A parent or other person legally liable to maintain a child, etc., is held to have neglected him in a manner likely to cause injury to his health if he fails to provide adequate food, clothing, medical aid, or lodging for the child. If unable to do so, he must apply to the Poor Law.

In the event of an indictment of manslaughter of an insured child being proved against a person having charge of the same the penalty is increased if the guilty person knows he would benefit pecuniarily by the insurance money.

Prosecutions can also be undertaken in the case of—

1. *Overlaying*—Any infant under 3 years of age who has been killed by overlaying by a person over 16 years of age who at the time of going to bed was under the influence of drink.

2. *Exposing Children to Risk of Burning*—If any person over the age of 16 years who has the custody, charge, or care of any child under the age of 7 years allows that child to be in any room containing an open firegrate not sufficiently protected to guard against the risk of the child being burnt or scalded without taking reasonable precautions against that risk, and by reason thereof the child is killed or suffers serious injury, he shall at least be liable to a fine not exceeding £10.

Failure to provide medical aid includes failure to carry out the medical directions given. Part III. deals with juvenile smoking, Part IV. with reformatory and industrial schools, Part V. with the treatment of juvenile offenders, Part VI. contains miscellaneous provisions. Section 122 gives power to an education authority through their medical officer to examine in any public elementary school provided or maintained by the authority the person and clothing of any child, and, if the child is infected with vermin or in a foul or filthy condition, to give notice in writing to the parent or guardian requiring him to cleanse properly the person and clothing of the child within twenty-four hours after receipt of the notice. If such notice is not complied with within twenty-four hours, the medical officer may remove the child, and may cause the person and clothing of the child to be properly cleansed. If, thereafter, the parent or guardian allows the child to become verminous, he is liable to a fine. The examination and cleansing of girls under this section may only be effected by a duly qualified medical practitioner, or by a woman duly authorised.

It may be pointed out, that not rarely power to keep the child cleansed depends on power being given to the Public Health Authority to ensure that the whole family shall be cleansed, and the articles of personal and bed clothing, mattresses, etc., in the household shall be disinfected.

VENEREAL DISEASES

The Royal Commission on Venereal Diseases issued its final report in February, 1916. Their conclusions were embodied almost in their entirety, in the Public Health (Venereal Diseases) Regulations, 1916, addressed to the councils of counties, county boroughs and the City of London. These regulations were issued by the Local Government Board under the Public Health Act, 1875, the Public Health (London) Act, 1891, the Public Health Act, 1896, and the Public Health (Prevention and Treatment of Diseases) Act, 1913. Their issue was accompanied by a circular and a memorandum of which certain points are at the present date of importance.[1] The treatment arranged should be available for the whole community and should be so organised that persons affected by these diseases will not be deterred from taking advantage of the facilities provided. The memorandum states that the Commission therefore recommended that the institutional treatment required should be at general hospitals. " In negotiating with the authorities of hospitals the council should therefore make it clear that the treatment must be for all comers, irrespective of the place of residence or the means of the patient. It will be important to arrange that the clinics are not specially designated as for venereal diseases, and that nothing is done to distinguish the patients who attend for treatment of these diseases. General practitioners are to be brought into the scheme, facilities afforded for their attendance at the clinics to be provided, and for consultations, and arrangements are to be made for practitioners to co-operate with the clinic in carrying out treatment.

It is recognised that the main difficulties in curing venereal diseases, and thus preventing their spread, are to ensure the application of patients for treatment at any early stage, and to maintain continued attendance until the doctor certifies that the patient is free from infection. If patients can afford to pay, they may properly be referred to a private practitioner, but, if the patient is unwilling, there should be no refusal to treat him at the institution.

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[1] See also Ministry of Health V.D. Circular 2, 14th January, 1918, urging local authorities to provide treatment for particular classes and cases.

Out-patient work at the clinic—The times should be made convenient to the patient, and some clinics should be held in the evening. They should be held *daily* in large centres, and are to be separate for each sex.

Hospital beds—A small provision should be made and as a minimum two, one for males, and one for females. It may be possible to arrange for beds elsewhere, the medical officer of the clinic attending.

The medical officer of the clinic should have satisfactory experience of venereal diseases. He is to be appointed by the committee of management of the hospital; the staff may comprise a visiting surgeon or physician and an assistant medical officer who is a whole-time or part-time salaried officer for venereal diseases. The medical officer is to keep records and be in close communication with the pathologist. There is great advantage, both as to efficiency and economy, in having material, especially for the Wassermann test, examined in a laboratory in which a large number of specimens are examined. The pathologist is to be personally responsible for the work.

Two considerations are apt to conflict here. It is desirable where possible that examinations for spirochætes and gonococci, and also cultures of gonococci, should be made at the clinic. In private cases arrangements should be made for these to attend at a central laboratory; if specimens submitted by practitioners are unsatisfactory, arrangements are to be made by the pathologist to rectify the omission.

The medical officer of the clinic should secure continued attendance. Every three months he is to transmit to the medical officer of health a report on the laboratory and medical work (to be in turn transmitted to the Ministry of Health). Every medical practitioner should be informed by the M.O.H. of the special facilities for diagnosis, consultation, and treatment open to him. He is to be informed that the facilities will include examination of fœtal tissues for spirochætes, and the making of Wassermann tests in the case of women who have had miscarriages. He is to be provided with appliances for taking specimens, and, when necessary, assisted in collecting materials. Treatment may be initiated at a clinic, and carried out subsequently by a practitioner on prescribed lines.

The duties of the medical officer of health in relation to the scheme are set forth. He is to organise a scheme of treatment in consultation with the medical officers of clinics, to arrange for the distribution of necessary appliances, to inform all medical practitioners of the arrangements provided, to give information to all persons who may be supposed to have an interest in the arrangements, to endeavour to secure the fullest use of the pathological facilities and of the facilities at clinics available to practitioners, to prepare reports, and to pursue a steady educational campaign. His annual report should contain information on the work of voluntary societies.

A venereal disease scheme for any locality comprises the following items :—

(1) The Treasury pays 75 per cent. of the cost.

(2) A local authority arranges for some general hospital to establish a clinic with the aid of the best medical staff available, who must satisfy the Ministry of Health as to their qualifications.

(3) It also arranges with a pathologist, who must be approved by the Ministry, to carry out Wassermann tests, and microscopical examinations of materials, the Wassermann tests to be on an approved system.

(4) The medical officer of health sees that all the arrangements, records and returns are satisfactory, and arranges financial details with the accountant or treasurer of the local authority. He makes returns to the Ministry as regards the work carried out, and the borough treasurer sends financial returns.

(5) The local authority arranges the details of propaganda work, usually by means of a local branch of the National Council for Combating Venereal Disease.

(6) The medical officer of health endeavours to secure arrangements for intermediate treatment, and to arrange for the attendance of local practitioners at clinics, and for their instruction in the methods of treatment.

There appears to be no doubt that the scheme of the Local Government Board for a venereal diseases service was the only one by which a general service could have been quickly arranged, and it may be maintained that it is the only reasonable one which could have secured a general interest on the part of the medical profession. On the other hand, in large centres there is much to be said for a scheme such as that of Col. Harrison at St. Thomas's Hospital, where attendance is continuous throughout the day, the staff arrangements and appliances are adequate and a laboratory is coupled with the clinical work, or the Edinburgh scheme in which a full-time medical venereal disease officer takes charge of the arrangements, and also of medical education in venereal diseases.

The scheme thus briefly indicated was framed, worked out to its minute details and is very largely administered by the Ministry of Health. The part played by the medical officer of health is purely that of an executive officer, although the deficiencies in local administration reflected on him. It was not at first found possible to carry out the proposals so fully as the Local Government Board desired. More especially in regard to gonorrhœa it was not found practicable to obtain all the facilities for ablution between visits, or, as it is called, "intermediate treatment," which was advised and is desirable, although this defect has been in part rectified.

J. NIVEN

The Public Health Act, 1925, amends the Public Health Acts, 1875 to 1907, and the Baths and Washhouses Acts, 1846 to 1899 in respect of matters for which provision is commonly made in local acts, and of other purposes relating to the public health.

The Act is divided into nine parts ; the first is "preliminary," then follow parts (2) streets and buildings ; (3) sanitary provisions ; (4) verminous premises, etc. ; (5) watercourses, streams, etc. ; (6) recreation grounds ; (7) infectious disease and hospitals ; (8) miscellaneous ; and (9) baths and washhouses ; parts 2 to 5 are adoptive in character.

With regard to (2) a local authority may provide and maintain, in any street, orderly bins for the collection and temporary disposal of street refuse or the storage of sand, etc. The provision in streets or public places, of seats, drinking fountains and watering troughs, and the erection of fire alarms after consultation with the local police authorities are also authorized. The naming of streets must be approved by the local authority, to whom is given the power of altering the name of a street, and who are required to indicate in a conspicuous position the street's name. The power conferred upon a local authority by section 25 of the Public Health Acts Amendment Act, 1907, of requiring the proper paving, etc., of a yard attached to a dwelling house is extended to any courtyard or passage containing two or more dwellings. An urban authority is empowered to require an owner to take all reasonable steps to prevent water from his premises from flowing over the footpath and to prevent soil, etc., from being washed into the streets. This part of the Act also deals with obstructions in streets. As regards new streets the local authority may require the street to be constructed at a greater width than that provided for by any existing byelaw or enactment, but if the additional width is more than 20 feet the local authority must pay reasonable compensation.

The powers under (3) relate to improperly constructed drains ; to the admission into sewers or drains connected therewith of any petroleum spirit or carbide of calcium ; and to requiring the proper ventilation of soil pipes to water closets. In urban districts an offensive trade shall be deemed to be established anew if it is transferred or extended to other premises, if it is resumed after discontinuance for more than six months, or if the premises are enlarged, and power is given to consent to the establishment of an offensive trade for a limited period, with, if considered desirable, power of extension from time to time.

Under (4)—verminous premises, etc., power is given for the cleansing, disinfection or destruction of verminous articles, compensation being payable in respect of damage to any article the condition of which is not attributable to the act or default of the owner.

Under (5) powers are given to urban authorities to require the filling up or covering of watercourses and ditches. None of the powers conferred by this part of the Act are exercisable with respect to any stream, watercourse, ditch or culvert which, by the Metropolis Management Act, 1855, is vested in the London County Council as a sewer, without the written consent of that Council.

Under part (6) a local authority is empowered to make charges in respect of expenses incurred for recreation purposes in respect of any public park or pleasure ground provided by them or under their management and control.

Part VII gives power (as regards persons suffering from tuberculosis in an infectious state who are lodged in such a condition that proper precautions cannot be taken or are not being taken) to a court of summary jurisdiction to make an order requiring the detention of the sufferer in a hospital for a period not exceeding 3 months and this period of detention may be extended from time to time for a further like period.

Part VIII allows a local authority or county council to arrange for the publication within their area of information on questions relating to health or disease and for the delivery of lectures and display of pictures in which such questions are dealt with.

With regard to baths and washhouses the local authority may make charges for their use, may close them between October and April and during closure may let them for other purposes.

It should be noted that Part IX *only* of the Act applies to the administrative County of London.

The Public Health Meat Regulations 1924 are made by the Minister of Health under the Public Health (Regulations as to Food) Act, 1907. They deal with (1) slaughterhouses and slaughtering ; (2) meat marking ; (3) stalls ; (4) shops, stalls, etc. ; and (5) transport and handling.

A slaughterer is required to give due notice to the local authority not less than three hours before slaughter takes place. He is also required to give notice forthwith if on slaughter it appears that any part of the carcass or internal organs appears to be diseased or unsound. Inflation of a carcass by the mouth or in any other manner likely to cause infection or contamination is prohibited as well as the use of the slaughterhouse for the killing of an animal not intended for human consumption.

Every person using a stall for the sale of meat must have his name and address legibly painted or inscribed thereon and must take steps to prevent mud, filth, or other contaminating substance, being splashed or blown from the ground on to the meat. He must guard against contamination of the meat by flies : and meat must not be placed on or within 18 inches of the ground or floor unless duly protected from contamination. As regards rooms in shops, stores, etc., similar precautions are prescribed and in addition possible risks from the existence of insanitary conditions are guarded against.

The packing or covering of meat so as to prevent uncleanliness is also dealt with, and every person who employs persons to carry meat in or about a market or similar place, or in any place used for the storage of meat before it is distributed to retailers, must cause such persons to wear clean and washable head coverings and overalls.

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